APPENDIX C

FWCAR

For The Lake Okeechobee Regulation Schedule Study

U.S. Army Corps of Engineers
Jacksonville District

June 2007

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

February 6, 2007

Colonel Paul L. Grosskruger
District Commander
U.S. Army Corps of Engineers
701 San Marco Boulevard, Room 372
Jacksonville, Florida 32207-8175

Service Consultation Code: 41420-2007-I-0323
Project: Lake Okeechobee Regulation Schedule

Dear Colonel Grosskruger:

The enclosed report is a draft Fish and Wildlife Coordination Act (FWCA) report on the Lake Okeechobee Regulation Schedule Study (LORSS) for your review. The draft FWCA report is based on the Tentatively Selected Plan as described and analyzed in the U.S. Army Corps of Engineers' (Corps') draft Supplemental Environmental Impact Statement (SEIS). This report is provided by the Fish and Wildlife Service (Service) in accordance with the FWCA of 1958, as amended (48 Stat. 401; 16 U.S.C. 661 *et seq.*) and the Endangered Species Act of 1973, as amended (ESA) (87 Stat. 884; 16 U.S.C. 1531 *et seq.*).

The Service, the Corps, the South Florida Water Management District, and other state and local entities have enjoyed extensive cooperation over the past year and a half to plan this project. This draft FWCA report provides the Service's continuing guidance and recommendations for the benefit of fish and wildlife resources related to Lake Okeechobee and the downstream ecosystems affected by water releases from the lake.

This report does not constitute a biological opinion as described under section 7 of the ESA. The Service is currently in the process of preparing a biological opinion for this project, which will address the project impacts on the Everglade snail kite (*Rostrhamus sociabilis plumbeus*). After consultation is concluded, if significant modifications are made to the selected plan or if additional information involving potential impacts to listed species becomes available, reinitiation of consultation may be necessary.

By copy of this report, the Service is soliciting comments within 45 days from the Florida Fish and Wildlife Conservation Commission and the National Marine Fisheries Service. Comments by those two agencies will be included as an appendix to our final report, which will then constitute the Secretary of the Interior's recommendations for the LORSS, in accordance with section 2(b) of the FWCA. The final FWCA report will be incorporated into the Corps' final

SEIS for public review and comment in accordance with the provisions of the National Environmental Policy Act.

If you or your staff has any questions regarding the findings and recommendations contained in this draft report, please contact Bob Pace at 772-562-3909, extension 239, or Doug Chaltry at 772-562-3909, extension 320. The cooperation of your staff and the staff of the South Florida Water Management District is greatly appreciated.

Sincerely yours,

Paul Souza
Field Supervisor
South Florida Ecological Services Office

Enclosure

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Draft Fish and Wildlife Coordination Act Report

2006 LAKE OKEECHOBEE REGULATION SCHEDULE STUDY

Submitted to:
Jacksonville District
U.S. Army Corps of Engineers
Jacksonville, Florida

Prepared by: Doug Chaltry, Margaret Wilson
Reviewed by: Bob Pace
Approved by: Paul Souza

Fish and Wildlife Service
South Florida Ecological Services Office
Vero Beach, Florida

February 2007

EXECUTIVE SUMMARY

The Fish and Wildlife Service (Service) has long been aware of the limitations of the current infrastructure surrounding Lake Okeechobee in dealing with extremes in climate and the inherent tradeoffs among competing project purposes. We have participated throughout formulation of alternatives, their evaluation, and modification to try to seek a reasonable balance in this "shared adversity." We applaud the U.S. Army Corps of Engineers (Corps) in reformulating the tentatively selected plan that was initially presented to the public in the fall of 2006. The Service was among several voices at that time that criticized its performance in simulations. We recognize the valid intent to reduce periods of high lake stage to also reduce the probability of a potential structural failure of the Herbert Hoover Dike that surrounds the lake. However, we consistently pointed out to the study team that the rigid constraint of having no days in the 36-year simulation with a lake stage above 17.25 feet also produced damaging high flow events of greater duration than in the No Action alternative. During reformulation and additional analysis in November and December 2006, the absolute constraint on stages over 17.25 feet was slightly relaxed, which allows us to say that none of the main ecosystems evaluated in the study are likely to suffer additional damage beyond the levels they are currently experiencing.

Although the above statement is not a ringing endorsement of the selected plan, it recognizes the limitations to correct the ecological problems surrounding Lake Okeechobee without very large additional storage areas, either above or below ground. One of the positive aspects of the revised schedule (beyond the additional security for the Herbert Hoover Dike) is the predicted increase in the total time, during periods of low rainfall, that the Minimum Flows and Levels criterion for the Caloosahatchee estuary can be met. Although we are pleased that the selected plan can still claim this as a benefit, we believe this goal is secondary to reducing damaging high flows to the Caloosahatchee. We can only claim that the selected plan is not predicted to be significantly worse than the No Action alternative for high flows under normal climate conditions. The selected plan is scheduled to be in effect for the next 3 years; except for years with heavy tropical storm activity, the Caloosahatchee estuary would likely benefit from the selected plan. However, if any of the next 3 years are extremely wet, then the lower Caloosahatchee estuary may suffer greater damage from high freshwater flows than with the No Action alternative. The St. Lucie estuary does not have a minimum flow criterion; the study team also avoided increasing the incidence of damaging high flow rates down the St. Lucie Canal, relative to the No Action alternative.

With respect to effects on the lake's ecologically valuable littoral habitat, the Service supports the idea that reduction of damaging high lake stages should be weighed more heavily in the evaluation of alternatives than the reduction of the period of stress to the ecosystem due to droughts. We recognize that the predicted reduction in the duration of damaging high lake stages is a benefit of the selected plan. But without additional water storage in the system, we have observed that lowering the peaks of the high lake stages generally cannot be accomplished without a concurrent lowering of the adverse low water levels during drought. Graphically, this is depicted as a lowering of the entire modeled stage hydrograph for the lake, with all its peaks and troughs. In the future, with more dynamic storage in the system, the intent is, on average, to compress both the extreme highs and lows towards a more ecologically favorable "lake stage

envelope." Therefore, the proposed revision to the schedule will likely perform better for the health of the lake during years with above average rainfall, but also will entail an increased risk of drying out the entire littoral zone more frequently during drought years. The Service agrees that periodically drying the littoral zone of Lake Okeechobee is ecologically beneficial. However, our analysis suggests that the lowering of the lake without additional storage around the lake runs the risk of drying the lake more frequently than is beneficial to a wide range of fish and wildlife that need the majority of the littoral zone to be inundated with shallow surface water during most years.

The Service looked closely at performance measures in the Water Conservation Areas and Everglades National Park. The modeling suggests that the changes are so small as to approach insignificance, often around a one percent difference. We believe that this is partly due to the lack of sensitivity and accuracy of the current model in detecting such small changes, but it is also partly due to practical constraints imposed on all of the evaluated alternatives. Sending water south to the remnant Everglades is strictly limited in the simulations due to the limited capacity to cleanse water through the existing set of treatment marshes.

We are providing a number of recommendations in this report, most of them focusing on ways to improve the analysis during the next phase (2007 to 2010) of formulating and selecting a lake regulation schedule that will incorporate the Band 1 projects of the Comprehensive Everglades Restoration Plan. We must keep in mind that the presently proposed schedule is expected to be in place for about 3 years. We also are well aware that the detailed comparisons we perform of model simulations are currently based on the precipitation patterns in the years 1965 to 2000. This allows the study team to look at the response of the alternatives to a wide range of climate cycles. We must recognize that this is in no way a prediction of climate conditions over the next 3 years. Model output analysis can only identify tendencies and probabilities, ranging from the probability of flooding in high rainfall years to the probability of water shortages in drought years. In the end, lowering of the average water stages in the lake with the presently proposed schedule will be judged a wise decision if the next 3 years predominantly include periods of high precipitation. Conversely, the attached report also includes a discussion of the increased risks to the ecology of the lake's littoral zone if the next 3 years include a period of drought.

Despite our inability to accurately predict long-range climate patterns (particularly in Florida's summer wet season), we are confident that the study team used the best available analytical tools and agency experts to reach the most favorable balance in the competing goals for the lake. Again, we appreciate the willingness of the Corps to reformulate alternatives until the consensus of the study team was that we had exhausted ideas to better balance overall performance.

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LIST OF ACRONYMS AND ABBREVIATIONS USED IN THE TEXT

af	acre-feet (325,851 gallons per acre-foot of water)
Alt-T3	Alternative T3
BO	Biological Opinion
C&SF	Central and Southern Florida
CERP	Comprehensive Everglades Restoration Plan
cfs	cubic feet per second
CLA	Class Limit Adjustments (modification to WSE)
Corps	U.S. Army Corps of Engineers
CSOP	Combined Structural and Operational Plan
District	South Florida Water Management District
EA	Environmental Assessment
EAA	Everglades Agricultural Area
EIS	Environmental Impact Statement
ENP	Everglades National Park
ESA	Endangered Species Act of 1973, as amended (87 Stat. 884; 16 U.S.C. 1531 *et seq.*)
F.S.	Florida Statute
ft	feet
FWC	Florida Fish and Wildlife Conservation Commission
FWCA	Fish and Wildlife Coordination Act
HHD	Herbert Hoover Dike
IOP	Interim Operational Plan
km	kilometers
LEC	Lower East Coast Service Area
LECRWSP	Lower East Coast Regional Water Supply Plan
LONINO	Lake Okeechobee Net Inflow Outlook
LORS	Lake Okeechobee Regulation Schedule
LORSS	Lake Okeechobee Regulation Schedule Study
LOWSM	Lake Okeechobee Water Shortage Management Plan
LWDD	Lake Worth Drainage District
MFL	Minimum Flows and Levels
NWR	National Wildlife Refuge
PAL	Planning Aid Letter
PDT	Project Delivery Team
ppb	parts per billion
ppt	parts per thousand (salinity)
SAV	Submerged Aquatic Vegetation
SEIS	Supplemental Environmental Impact Statement
Service	Fish and Wildlife Service
SFWMM	South Florida Water Management Model
SSM	Supply Side Management
STA(s)	Stormwater Treatment Area(s)
TSP	Tentatively Selected Plan
WCA(s)	Water Conservation Area(s)
WSE	Water Supply and Environment (the regulation schedule from 2000 to present)

I. PURPOSE, SCOPE, AND AUTHORITY

A. Introduction

The U.S. Army Corps of Engineers (Corps) is preparing a Supplemental Environmental Impact Statement (SEIS) for the Lake Okeechobee Regulation Schedule (LORS). The intent of this SEIS was to evaluate new alternatives for the Lake Okeechobee regulation schedule "in order to optimize environmental benefits at minimal or no impact to the competing project purposes, primarily flood control and water supply" (Corps 2005). However, the study underwent a change during the course of alternative development and evaluation, resulting in an increased emphasis on lowering high lake stages to protect the integrity of the Herbert Hoover Dike (HHD) that surrounds the lake. The project alternatives considered only operational changes to water management structures that discharge water from the lake, and no new construction is planned. This schedule will be active for 3 years (2007-2009), and a new schedule, which will incorporate possible structural improvements along with benefits from initial components of the Comprehensive Everglades Restoration Plan (CERP), will be implemented in 2010.

The proposed water regulation schedule will replace the current schedule referred to as the Water Supply and Environment (WSE) regulation schedule. The tentatively selected plan (TSP), known as Alternative T3 (or Alt-T3) in this study, was identified by the study team to be the alternative that best met the constraints set by the Corps for public safety of the HHD, while at the same time minimizing adverse impacts to water supply, navigation, recreation, fish and wildlife resources in the littoral zone of Lake Okeechobee, and the St. Lucie and Caloosahatchee Estuaries.

B. Purpose and Scope of Project

The purpose of the Lake Okeechobee Regulation Schedule Study (LORSS) is to determine if an improved regulation schedule can better accommodate the wide range of extreme weather events that have affected south Florida since the adoption of the WSE regulation schedule 6 years ago. As stated in the Introduction to this section, the original purpose of the study was to develop a regulation schedule that better balanced the multiple, and sometimes competing, objectives for managing water levels in Lake Okeechobee, with emphasis on environmental benefits. The revised project purpose gave greater consideration to lowering lake stage such that acceptable alternatives had to meet the Corps' intent to further protect the HHD from extreme precipitation events.

To allow expeditious development and implementation of the new regulation schedule, the Corps decided to limit the scope of the project to evaluating only those alternatives that are feasible without changes to the physical infrastructure of canals, levees, pumps, and water control structures around Lake Okeechobee. The geographic scope of the analysis of the alternatives includes Lake Okeechobee itself, the St. Lucie and Caloosahatchee estuaries, the Water Conservation Areas (WCAs), and Everglades National Park (ENP).

C. Authority

As described in the Notice of Intent for this project (Corps 2005), "Authority for this action is the Flood Control Act of 1948. It authorized the Central and Southern Florida (C&SF) Project, which is a multipurpose project that provides flood control, water supply for municipal, industrial, and agricultural uses; prevention of salt water intrusion; water supply for ENP; and protection of fish and wildlife resources."

The Fish and Wildlife Service (Service) believes that Congress has not imposed a specific limitation on the authority to address the ecological and water supply issues associated with Lake Okeechobee. Rather, the Service believes that the Corps limited the scope of the LORSS to only operational changes, thereby allowing more expeditious development and implementation of a superior regulation schedule. Nevertheless, the Service is obliged to provide in this report both short-term and long-term recommendations to conserve and enhance fish and wildlife resources in Lake Okeechobee, consistent with the restoration goals of the CERP.

II. PREVIOUS SERVICE INVOLVEMENT WITH THE LAKE OKEECHOBEE REGULATION SCHEDULE

A. Overview

The Service has a long history of reviewing and providing recommendations to the Corps on the effects of water regulation in Lake Okeechobee. There has been a single, formal consultation in 1978, when the Service provided a biological opinion (BO) finding that implementation of the regulation schedule proposed at that time would not jeopardize the endangered Everglade snail kite (*Rostrhamus sociabilis plumbeus*). That regulation schedule is often referred to as the 1978 Schedule.

The 1978 formal consultation was followed by 20 years of informal endangered species consultations and advisement. The Service provided several Planning Aid Letters (PALs) and Fish and Wildlife Coordination Act (FWCA) reports to the Corps addressing various modifications to the regulation schedule, including the extensive plan formulation and in-depth analysis leading to the selection of the WSE schedule in 1999. The Service generally supported the changes to the schedule, sometimes after extended periods of analysis and plan development, and at other times involving either minor modifications or temporary deviations requested by the Corps in response to particular circumstances. It is important to note that Service policy on the format and content of Incidental Take Statements was not in effect at the time of the 1978 formal consultation; these provisions arose from the Endangered Species Act (ESA) amendments of 1982. The final regulations governing incidental take statements were published in the *Federal Register* on June 3, 1986. An informal consultation was conducted on the regulation schedule in 1999, in conjunction with a FWCA report, when the WSE regulation schedule was evaluated. We are currently preparing the only formal consultation since 1978, addressing the currently proposed regulation schedule, and this will include an Incidental Take Statement.

B. Chronology

The following chronology includes only the major milestones since 1978. Many additional meetings and correspondence are not included in this list.

On March 8, 1978, the Service issued a BO on the Corps' proposal to raise the LORS from the 14.5 - 16.0 feet (ft) schedule to the 15.5 - 17.5 ft, 1978 schedule (all elevation measurements in this report are expressed in National Geodetic Vertical Datum). The BO was limited to consideration of effects on the endangered snail kite, and concluded that the action was not likely to jeopardize the continued existence of this species. However, the Service also expressed concern that it was difficult to predict the exact response of apple snail (*Pomacea paludosa*) populations to the new regulation schedule, and we recommended that the Corps initiate an apple snail monitoring program in the lake's littoral zone, which was designated as critical habitat for the snail kite in 1977.

On June 19, 1978, the Service provided an FWCA report in response to the proposed 1978 schedule. The Service did not oppose implementation of the 1978 schedule, but called for monitoring of apple snails, the vegetative composition in the littoral zone, the fisheries in the marsh, and bird rookeries and other breeding areas. The Service also recommended management of water levels within the levees at Torry, Kreamer, and Ritta Islands in the southeastern portion of the lake to create additional marsh habitat.

On September 5, 1985, the Service provided a PAL to the Corps regarding the potential adverse environmental effects of raising the lake's regulation schedule from the 15.5 - 17.5 ft schedule, then in effect, to a 19.5 - 21.5 ft schedule, as part of an effort to increase water supply in south Florida. The PAL cited evidence suggesting that the 1978 schedule, which had at that time been in effect for nearly 6 years, was causing adverse effects on the littoral marsh and its associated fish and wildlife resources. We recommended long-term monitoring of the effects of the 1978 schedule, and recommended against the 19.5 to 21.5 ft schedule, which the Service predicted would eliminate about 55,600 acres of littoral wetlands, including willow-vegetated bars used by wading birds and the snail kite for nesting. The PAL also noted that the Corps had not carried out the Service's 1978 recommendation to partially compensate for adverse effects caused by the 1978 schedule through restoration of marshes at Torry, Kreamer, and Ritta Islands, nor had they yet implemented any apple snail monitoring program.

On June 10, 1987, the Service sent a letter to the South Florida Water Management District (District), requesting re-evaluation of the 1978 schedule, based on the observed stress on the vegetation in the littoral zone.

In 1988, the Lake Okeechobee Littoral Zone Technical Group, a group of wetland and wildlife scientists (including the Service), recommended adoption of a lower lake regulation schedule, known as Run 22, which would operate in zones between 13.5 ft and 15.5 ft.

In 1992, a schedule known as Run 25 was implemented for a two-year trial period, instead of the recommended Run 22.

On March 18, 1993, the Corps, responding to a request from the District, called for comments on the Run 22 schedule.

On May 14, 1993, the Service sent a letter to the Corps stating that Run 22 or a similar schedule would apparently be preferable to the Run 25 schedule for protection of the littoral zone. The letter requested that the Service and the Corps develop a Scope of Work to prepare a draft FWCA report on Run 22. Although our files contain copies of a draft Scope of Work, we believe this was never finalized and that the Service never prepared an FWCA report evaluating Run 22.

In May 1994, the Corps held two public hearings on the continued use of Run 25 as the lake's regulation schedule. One of the alternatives considered in that review was Run 22AZE, a modification of Run 22. Following the public hearings, the Corps extended the use of Run 25.

The Lake Okeechobee Regulation Schedule Study (LORSS) began with a June 14, 1995, public notice requesting comment on the alternatives that were then under consideration.

The Corps, through a contract with Lotspeich and Associates, conducted eight week-long sampling efforts in the lake's littoral zone between May 1997 and November 1998. This provided baseline data on vegetation and general observations of fish and wildlife prior to plan formulation for the LORSS. The study did not include sampling for apple snails and included only recorded observations of snail kites in general avifauna surveys. The final report was issued in June 1999, after the Corps had selected a preferred alternative under the LORSS.

On September 24, 1997, the Florida Game and Fresh Water Fish Commission (now the Florida Fish and Wildlife Conservation Commission, or FWC) and the Service jointly sent a PAL to the Corps, which noted that the FWC and the Service preferred Run 22AZE overall among the alternatives then under consideration.

On April 15, 1998, the District presented preliminary results of simulations of a newly devised alternative, named WSE. Lacking adequate time to fully evaluate the newly introduced WSE alternative, both the FWC and the Service stated to the Governing Board that Run 22AZE remained their preferred alternative.

On September 23, 1998, the Service provided a PAL in response to discussions at a meeting on September 11, 1998, involving development of an implementation strategy for the WSE schedule.

On February 18, 1999, the Corps officially notified the Service that the WSE schedule would be the preferred alternative in the draft EIS for the LORSS. That letter also stated the Corps' determination that the WSE schedule was not likely to adversely affect federally listed threatened or endangered species.

In July 1999, the Service received a copy of the draft EIS for the LORSS. The draft FWCA report had not been completed prior to issuance of the draft EIS.

On July 30, 1999, the Service issued the draft FWCA report on the LORSS. This report concurred with the Corps' determination that implementation of the WSE water regulation schedule was not likely to adversely affect federally listed threatened or endangered species or result in destruction or adverse modification of designated critical habitat. This was based on the data showing that WSE would show slight improvement in damaging high water levels relative to the previous Run 25 schedule. Because consultation under section 7 of the ESA was concluded informally, we did not prepare an incidental take statement at that time.

On October 6, 1999, the Service issued the final FWCA report on the LORSS. The Service recommended that the Corps refine their climate forecasting methodology, conduct studies to quantify the effects of lake levels on various flora and fauna, and conduct research on lake phosphorus levels. The Service also reiterated our previous recommendations to mitigate adverse effects caused by the 1978 schedule through restoration of marshes at Torry, Kreamer, and Ritta Islands.

After several years of above average rainfall and sustained high water levels, the FWC requested by letter on March 27, 2000, that the Corps investigate a managed recession of lake levels. This was discussed in a public technical meeting at the District on April 11, 2000. The District Governing Board approved the Shared Adversity Plan in April 2000, with the goal of lowering Lake Okeechobee from 14.89 to 13 feet, and holding it at 13 feet for eight weeks to promote the reestablishment of submerged aquatic vegetation and thereby benefit fish and wildlife. The Service supported this plan and praised the Governing Board for assuming risks to benefit the lake's ecology. The plan largely accomplished its intended ecological benefits despite two less than desirable characteristics. First, climate predictions proved to be incorrect, and rainfall was not available to hold the lake at 13 ft. Lake stage plummeted to a record low around 9 ft in May 2001. Due to water supply concerns, the District allowed backpumping of water from the Everglades Agricultural Area (EAA) to the lake and temporary forward pumps that allowed delivery of water to the EAA below stages that would be accommodated by the permanent structures on the south side of the lake. The lake stage rose abruptly (good for water supply, but perhaps too fast for maximal ecological benefit) following late wet season rains. Nevertheless, the lake stage rose to a desirable level without extended periods of environmentally damaging high stages, and submerged aquatic vegetation (SAV) responded the following spring with greatly increased coverage under excellent water clarity conditions.

The Adaptive Protocols for Lake Okeechobee Operations were accepted by resolution of the Governing Board of the District on January 9, 2003. The Adaptive Protocols provide additional guidance on the consultative process water mangers in the District use to decide specific water release volumes within the range of operations allowed under WSE.

On December 8, 2003, the Corps asked the Service to review a temporary deviation from the WSE schedule that would allow Level I Pulse Releases to the St. Lucie and Caloosahatchee estuaries under circumstances not normally considered under WSE. In a December 15, 2003,

letter, the Service agreed that the action was likely to provide a net benefit to the system, with benefits mainly in the lake's littoral zone and relatively low risk of harm to the estuaries due to the moderate discharge volumes. The low level releases were also considered beneficial in attempting to reduce the need for higher volume releases later in the wet season.

On May 13, 2004, the Corps issued a letter requesting extension of the temporary deviation until May 31, 2005. The Service concurred with this request on June 2, 2004. The low volume releases would preclude or lessen high volume regulatory discharges to the Caloosahatchee and St. Lucie estuaries.

On September 10, 2004, the Corps provided the Service information regarding the temporary deviation, and a draft Environmental Assessment (EA) that analyzed the Class Limits Adjustment (CLA) alternative, which was a new proposal to adjust the WSE to allow improved water release decisions, mainly on the basis of reclassification of parameters in the decision tree for WSE related to the Lake Okeechobee Net Inflow Outlook (LONINO) and tributary conditions in the Kissimmee River watershed. The Corps concluded that the CLA alternative would not adversely affect listed species or critical habitat, and they requested our review of the EA and comments.

On November 1, 2004, Service provided comments on the draft EA for the CLA proposal. Our evaluation concluded that, while the CLA may result in minor negative effects to the estuaries, these effects would be offset by beneficial ecological effects (also minor) within the lake.

In November 2004, the Florida Wildlife Federation sent letters to the Corps and the Service's Regional Director expressing their great concern over the current status of the Everglade snail kite, and impacts to the kite from water management in Lake Okeechobee. They urged the two agencies to lower the average lake elevation to pre-1978 levels, and to ensure the continued availability of irrigation water through the use of forward pumps, as had been demonstrated during the 2001 drought.

On December 2, 2004, the Corps sent a letter to the Service that included additional information on their effects determination of the CLA on listed species, and requested our concurrence with their determination of "no effect" on the Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*), West Indian manatee (*Trichechus manatus*) and eastern indigo snake (*Drymarchon corais couperi*), and a "not likely to adversely affect" determination on the snail kite, bald eagle (*Haliaeetus leucocephalus*), wood stork (*Mycteria americana*) and Okeechobee gourd (*Cucurbita okeechobeensis* ssp. *okeechobeensis*).

The Service responded to the Corps on January 20, 2005. This letter reminded the Corps of our previous request from past years for the Corps to implement a monitoring study on the apple snail within the littoral zone of the lake, which has not been carried out to date. We also informed the Corps that the most current scientific information available indicates that the snail kite is faring poorly in Florida, particularly in the littoral zone of Lake Okeechobee, which was historically one of the largest kite breeding areas in the state. We recommended that the Corps immediately reinitiate formal consultation on the Lake Okeechobee regulation schedule, and

agreed that the CLA should be implemented as an interim conservation measure while we continue into formal consultation.

On June 15, 2005, the National Wildlife Federation filed a 60-day Notice of Intent to sue the Corps for violating the ESA by failing to protect the snail kite on Lake Okeechobee. Their specific charges against the Corps were the failure to reinitiate consultation on the 1978 regulation schedule, the illegal take of snail kites because the Service never issued an incidental take statement to the Corps, and for failing to implement a snail kite conservation program.

On July 21, 2005, the Corps sent a letter to the Service and other stakeholders requesting our initial input on concerns regarding the WSE regulation schedule, and opinions on how problems with the schedule may be addressed.

On August 3, 2005, the Corps issued a Notice of Intent to prepare a Draft SEIS that stated their intention to evaluate new alternatives for the LORS "in order to optimize environmental benefits at minimal or no impact to the competing project purposes, primarily flood control and water supply."

The Corps sent a species list request to the Service on August 29, 2005, and the Service responded by letter with the species list on September 30, 2005.

The Service sent a letter to the Corps on September 19, 2005, in response to their July 21, 2005, request for initial comments, providing a discussion of our views and issues on the lake regulation schedule. A Project Delivery Team (PDT) was established to develop and analyze alternatives to the WSE regulation schedule, of which the selected alternative would be implemented for the 2007-2009 timeframe. The PDT was composed of representatives from the Corps, the Service, the District, and other local, state and federal agencies.

On March 8, 2006, the Corps requested informal consultation concerning a new regulation schedule, with the stated goal to "plan measures to further improve the environmental performance of the [WSE] regulation schedule."

On May 16, 2006, the Service's Regional Director sent a letter to the Corps' District Engineer, recommending selection of Alternative 1aS2 for the new regulation schedule. The Service considered all ecological effects, both within and outside Lake Okeechobee, of the many alternatives that had been modeled. Of particular concern to us was the effect of lake releases on the downstream estuaries, and in lieu of providing actual restoration of these estuarine systems, we emphasized that the selected plan should at least not cause any additional damage to the estuaries than the "future without project" condition. At that time, we believed that the PDT had reached consensus that Alternative 1aS2 was the best "all around" alternative, providing the best balance between slightly lowering the lake stage and limiting large volume discharges to the estuaries to no worse than the No Action alternative.

In mid-May 2006, the Corps' project manager explained to the LORSS project team that the Corps had changed its emphasis regarding project goals in recognition of the perceived threats to

the integrity of the HHD. Consequently, those alternatives that did not lower the lake stage to the extent deemed necessary to protect public safety were eliminated from further consideration, including Alternative 1aS2.

On June 30, 2006, the Corps requested initiation of formal consultation on the LORS, and submitted a Biological Assessment (BA) presenting their analysis of the effects of the recommended plan on several listed species. The alternative that was chosen as the recommended plan was known as Alternative 1bS2-m. The Service acknowledged the receipt of the BA and began formal consultation on July 21, 2006.

On August 10, 2006, the Corps published the Draft SEIS for public review. A draft FWCA report was not completed in time for inclusion in the Draft SEIS. The Service submitted comments on the Draft SEIS as part of a unified comment letter from the Department of the Interior. Public comments on the proposed TSP were overwhelmingly negative, with the majority coming from residents and organizations on the Florida Gulf coast, due to increased negative impacts that the proposed TSP would have on the Caloosahatchee River and estuary.

In late October 2006, the Corps project team recommended to Corps management that the PDT should reformulate the project alternatives, devise an improved TSP to address the public concerns, and to prepare a revised draft of the SEIS to be published for another 30-day public review.

Throughout November and December 2006, the PDT developed and analyzed several new variations of the project alternatives. Following a public comment period and preparation of a final SEIS, the Record of Decision for the new schedule should be approved in July 2007.

III. AREA SETTING

A. Project Location

The study area for this project includes Lake Okeechobee, the Caloosahatchee Estuary, the St. Lucie Estuary, the EAA, and the WCAs south of Lake Okeechobee. Lake Okeechobee is located in south-central Florida, about 100 kilometers (km) south of Orlando, and 60 km northwest of Miami, within Okeechobee, Glades, Palm Beach, Martin and Hendry Counties. Figure 1 shows some of the more prominent natural features of the Lake Okeechobee area and the location of the most prominent surrounding natural habitat areas.

B. Description of Study Area

1. Hydrological Description

Lake Okeechobee is the central feature of south Florida's interconnected Kissimmee River/Lake Okeechobee/Everglades watershed. Lake Okeechobee is a shallow subtropical lake that supplies water to the remnant Everglades, Florida Bay, and the St. Lucie and Caloosahatchee estuaries. Lake Okeechobee is completely surrounded by the HHD, and all its inflows (except for

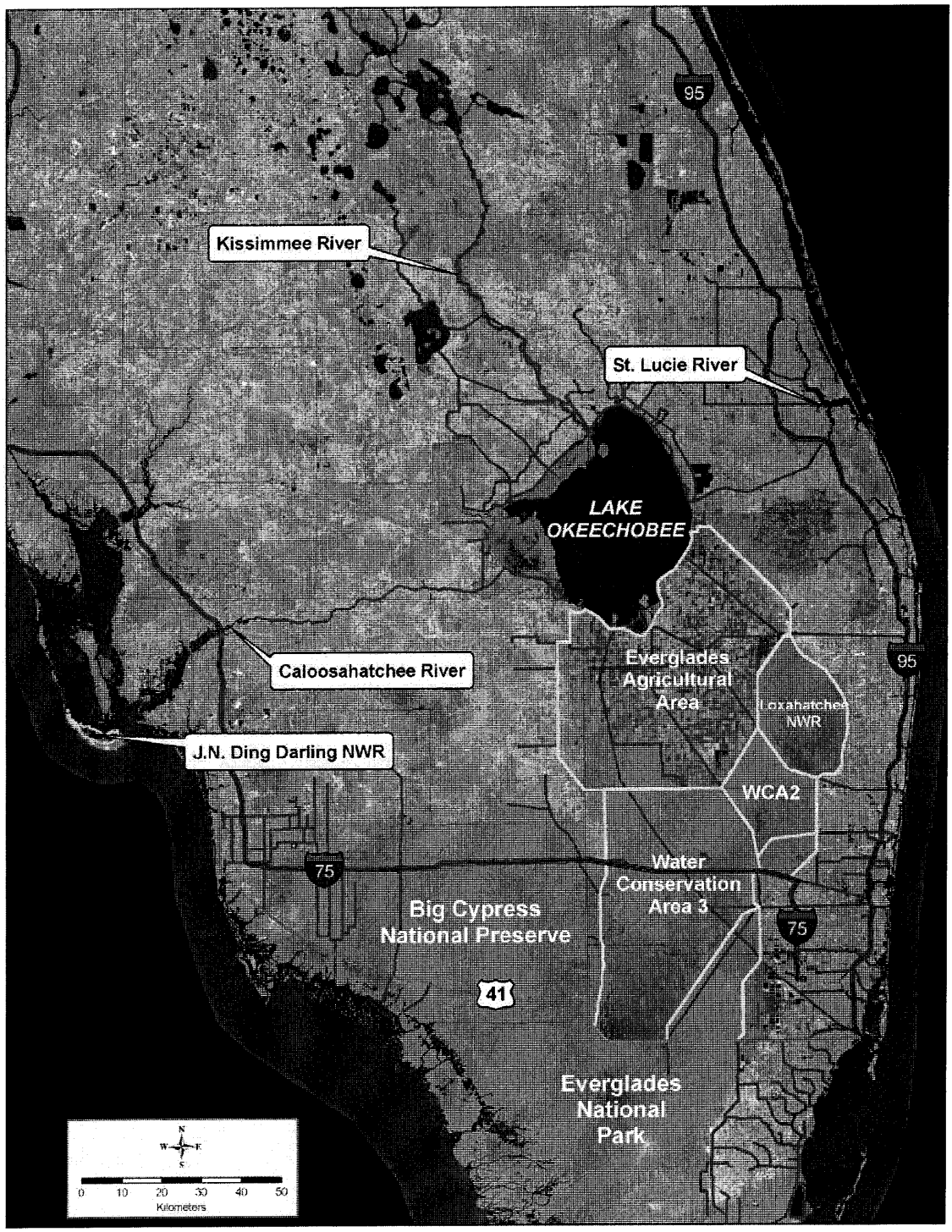

Figure 1. Lake Okeechobee and surroundings.

Fisheating Creek) and outflows are controlled by an extensive system of levees, canals, water control structures, and large pump stations. During the wet season, the surface area of the lake extends to the dike on all sides of the lake, and the maximum surface area is approximately 1,730 km^2, though the volume of the lake will increase with the depth. During the dry season, the surface area will decrease considerably, dependent upon the water depth.

The 12,000 km^2 Kissimmee River drainage basin that feeds Lake Okeechobee lies north of the lake, and is dominated by dairy and beef operations. The 2,800 km^2 EAA is south of the lake, where water from the lake supports sugar, rice, and winter vegetable crops. The St. Lucie estuary is located northeast of Lake Okeechobee, and is connected to the lake by the St. Lucie canal (C-44), which discharges into the South Fork of the estuary. The estuary flows into the Indian River Lagoon and Atlantic Ocean at the St. Lucie Inlet. The Caloosahatchee Estuary is located southwest of Lake Okeechobee on the Gulf coast. The Caloosahatchee River (C-43) extends from Lake Okeechobee to the Franklin Lock and Dam (S-79) where it empties into the estuary.

There are six constructed wetlands known as storm water treatment areas (STAs) downstream of Lake Okeechobee. The purpose of these STAs is to treat the water from Lake Okeechobee prior to releasing the water south into the WCAs. Since 1994, these constructed wetlands have reduced the total phosphorus load that would have gone into the Everglades by over 600 metric tons (District 2006a). Lake Okeechobee will contribute a significant portion of the water anticipated to be captured and treated in the STAs. A better understanding of the temporal and spatial characteristics of the water leaving the lake is needed for updated STA performance projections (District 2006a).

Because of the integrative nature of the regional system, management of the STAs is critical to providing water quality improvements. In addition, the District anticipates that all future Lake Okeechobee releases, whether they are pursuant to the Lake Okeechobee regulation schedule, Best Management Practices in the EAA, replacement water, or for water supply to downstream receiving areas, will be directed through the existing STAs prior to discharge to the Everglades Protection Area, when practical (District 2006a). Because of the critical nature of managing the STAs to ensure water quality criteria are met, the TSP for the Lake Okeechobee regulation schedule will take into account the general operational principles that are currently in place for the STAs.

2. Ecological Description

Pre-development Lake Okeechobee was considerably larger in surface area, with a littoral zone that extended over a wide expanse of low-gradient land to the north, west, and south of the lake's open water region (Havens et al. 1996a). The marsh and swamps that once surrounded the lake are now separated from the lake ecosystem by the HHD, and have been converted to urban and agricultural land uses. Today's remaining 400 km^2 littoral zone is a unique wetland that has been formed since impoundment of the lake. Lake Okeechobee is a critical concentration point for winter waterfowl along the Atlantic flyway and supports feeding and nesting of wading birds.

The southwestern littoral zone of the lake comprises part of the critical habitat of the endangered Everglade snail kite.

3. Fish and Wildlife Resources

a. Federally Listed and Candidate Species

The Service identified six federally listed species that occur within the area of effect for this project. A forthcoming BO for this project will evaluate the effects of the recommended plan on the:

- Everglade snail kite (*Rostrhamus sociabilis plumbeus*)
- wood stork (*Mycteria americana*)
- bald eagle (*Haliaeetus leucocephalus*)
- West Indian manatee (*Trichechus manatus*)
- Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*)
- eastern indigo snake (*Drymarchon corais couperi*)
- Okeechobee gourd (*Cucurbita okeechobeensis* ssp. *okeechobeensis*)

In addition to those species regulated by the Fish and Wildlife Service, we have encouraged the Corps to consult with the National Marine Fisheries Service regarding possible effects of the project on sea turtles in both estuaries, and Johnson's seagrass (*Halophila johnsonii*) within the St. Lucie estuary and/or Indian River Lagoon.

b. State-listed Species

The following species are listed by the State of Florida and are expected to occur in the project area:

- American alligator (*Alligator mississippiensis*)
- roseate spoonbill (*Ajaia ajaja*)
- limpkin (*Aramis guarauna*)
- little blue heron (*Egretta caerulea*)
- reddish egret (*Egretta rufescens*)
- snowy egret (*Egretta thula*)
- tricolored heron (*Egretta tricolor*)
- white ibis (*Eudocimus albus*)
- Florida sandhill crane (*Grus canadensis pratensis*)
- brown pelican (*Pelecanus occidentalis*)
- black skimmer (*Rynchops niger*)
- Florida pine snake (*Pituophis melanoleucus mugitus*)

c. Other Fish and Wildlife Resources

Lake Okeechobee provides habitat for fish and wildlife resources of direct monetary value (commercial and recreational fisheries, waterfowl hunting, alligator hunting) and of inestimable indirect value in terms of tourism, quality of life, and the survival of many threatened, endangered, and rare species. Furse and Fox (1994) estimated the value of five different vegetative communities in the lake in supporting the commercial and recreational fisheries, which they then estimated to have a "total economic value" in excess of $480 million. The economic effect of a healthy lake ecosystem on non-consumptive recreational activities in the lake may be more difficult to measure, but it is becoming more significant. Examples of non-consumptive uses of the lake include airboat tours, birding expeditions, and educational field trips.

IV. FISH AND WILDLIFE RESOURCE CONCERNS

A. Introduction

Lake Okeechobee is the heart of the water management system of central and south Florida, and the lake's regulation schedule has implications for fish and wildlife values throughout south Florida. Adverse effects of drought or wet seasons with extremely high rainfall can affect the lake for either short periods or for durations of two or more years. Regulatory releases from the lake can have dramatically adverse consequences in the St. Lucie and Caloosahatchee estuaries, but as explained below, water management in the drainage basins of the estuaries also contributes to ecological problems within the estuaries. The influence of water management in the lake can also affect hydropatterns in the Everglades. The Lake Okeechobee conceptual model (Havens and Gawlik 2005) demonstrates the complex interactions among various environmental stressors affecting the lake. Therefore, division of the discussion into the following subsections of the report describing the Service's resource concerns is somewhat artificial, due to the high level of interaction among many of these factors.

B. Resource Concerns

1. Direct Effects of Lake Stages on the Lake Okeechobee Littoral Zone

The littoral zone of Lake Okeechobee is highly productive, sustains a great diversity of fish and wildlife, and is the area most affected by changes to the lake's regulation schedule. Changes in water depth and the duration of inundation control the vegetative communities of the littoral zone, the total area of the lake available as habitat for aquatic animals, and the availability of aquatic prey for higher consumers, particularly wading birds. Havens et al. (1996b) found that the littoral zone had a greater trophic complexity than open water habitats. Many of the additional species in the littoral zone that are not found in the pelagic zone are large predators (14 species of adult fish and 14 species of birds), but the majority of the additional taxa (54) are macroinvertebrates. The effects of water regulation in the lake on phytoplankton, periphyton, and benthic invertebrates are passed through the food web to readily observable losses in biodiversity at higher trophic levels.

During periods of extreme high lake levels (>17 ft), wind and erosion cause emergent and submerged plants to be torn loose from their substrates, resulting in a loss of important fish and wildlife habitat. When lake levels exceeded 17 ft in 1995 and 2004, large sections of bulrush (*Scirpus californicus* and *S. validus*) were lost. These plants occur at the interface between the pelagic and littoral zones where they are exposed to wave action, and constitute prime habitat for largemouth bass (*Micropterus salmoides*) and black crappie (*Pomoxis nigromaculatus*), two of the most important recreational fishes in the lake (Furse and Fox 1994). Following the drought of 2000-2001, the largemouth bass population began recovery after three years, because of the delay in re-colonization by SAV (Havens et al. 2005).

Extremely low lake levels (<11 ft) expose 95 percent of the littoral zone to desiccation, rendering the majority of the area unavailable as habitat for fish and waterfowl. One of the aquatic communities that becomes dry when the lake is at 11 ft is dominated by spike rush (*Eleocharis cellulosa*). This community is of particular concern because it supports a large population of apple snails, the primary food resource for the endangered snail kite. Spike rush is particularly valuable habitat for foraging snail kites because its moderate stem density accommodates the kite's visual hunting behavior. Maintaining clear water, sandy-bottom littoral habitat with emergent vegetation is necessary to support a healthy apple snail population (Darby et al. 2004).

However, as damaging as low water elevations are to the lake's littoral ecosystems, excessively high water elevations can be even more destructive. Steinman et al. (2002) list five possible ecological effects from extended periods of high water levels within Lake Okeechobee:

- Less light reaches the bottom of the lake, resulting in loss of submerged vegetation;
- Increased turbidity results in light limitation of bulrush (*scirpus* spp.), which may weaken the plants, making them more susceptible to uprooting by wind-driven waves;
- Increased phosphorus concentrations in the nearshore regions, as phosphorus-rich sediments are transported from the central mud zone toward the littoral zone;
- Internal waves within the lake's water column spread sediments from the center of the lake to shoreline areas where much of the lake's submerged plants and fish/wildlife habitat occur; and
- Possible reduced rate of spread of invasive species in the lake's marsh zone, such as torpedo grass (*panicum repens*) and *melaleuca quinquenervia*, both of which can tolerate flooded conditions, but appear to increase in coverage following dry conditions.

In addition to the detrimental effects that occur from the short-term extreme events, the lake was subjected to the 15.5 ft to 17.5 ft water regulation schedule from 1978 to 1992. This regulatory period demonstrated the deleterious effects of a prolonged period of moderately high lake stages. Milleson (1987) documented vegetation changes along the Moore Haven and Indian Prairie transects in the littoral zone, as compared with conditions found by Pesnell and Brown (1977).

Milleson found a loss of spike rush, an expansion of cattail (*Typha domingensis*), and invasion by the exotic torpedo grass. Torpedo grass is poor habitat and cannot support the fish and wildlife populations that are found in native vegetation. Milleson attributed these changes to prolonged inundation of the littoral zone by stages over 15 ft with the 15.5-17.5 ft regulation schedule, which had then been in effect since 1978. He predicted that reduced diversity of the marsh vegetation would adversely affect waterfowl, wading birds, reptiles, fish, and other species that depend on a diverse marsh.

On the basis of Milleson's observations and subsequent evaluations of littoral zone vegetation (Richardson and Harris 1995; Richardson et al. 1995), the Service believes that prolonged periods of lake stages over 15 ft favor less diverse, more permanently flooded wetland communities, rather than the more diverse vegetation produced in alternately flooded and exposed portions of the littoral marsh. The reduction in the proportion of the littoral zone vegetated by willow (*Salix caroliniana*) in the early 1970s has been attributed to higher lake stages (Richardson and Harris 1995; Richardson et al. 1995). Willows are important nesting sites for the endangered snail kite and several species of wading birds. David (1994a, 1994b) found that by 1988 wading birds no longer nested in the willows at the King's Bar colony, which contained nearly 10,000 nests in 1974 and 6,000 nests in 1978 (excluding cattle egret [*Bubulcus ibis*]). He attributed this loss of the larger nesting colonies to the 1978 regulatory schedule.

In addition to the adverse effects on wading bird nesting habitat due to changes in vegetation, several studies indicate additional adverse effects of sustained high lake stages on feeding by wading birds. Zaffke (1984) found that successful wading bird feeding in the littoral zone depended on receding lake stages below 15 ft and suggested that the 15.5-17.5 ft schedule, which had then been in effect since 1978, was detrimental to feeding and nesting wading birds. This observation has been supported in subsequent studies by Smith et al. (1995) and Smith and Collopy (1995).

Bull et al. (1995) found significant negative correlations between water depth at sample sites in the lake's pelagic zone and the abundance of threadfin shad (*Dorosoma petenense*) and bluegill (*Lepomis macrochirus*), while increased depth was positively correlated with abundance of white catfish (*Ameiurus catus*) and black crappie (*Pomoxis nigromaculatus*). Additional study is needed on the effect of lake stage on the standing stock and reproductive success of fish in the littoral zone.

2. Minimum Flows and Levels for Lake Okeechobee

Florida law requires the water management districts to establish Minimum Flows and Levels (MFLs) for surface waters and aquifers within their jurisdiction (section 373.042(1), *Florida Statute* [*F.S.*]). The minimum level is defined as the "limit at which further withdrawals would be significantly harmful to the water resources of the area." Section 373.0421(2), *F.S.*, provides that if it is determined that water flows or levels will fall below an established MFL within the next 20 years or is presently below the MFL, the water management district must develop and implement a recovery or prevention strategy.

In addition to low-water effects on water supply and navigation, significant harm may also occur to the lake's littoral zone when lake levels fall below 11 ft. When lake levels drop to 11 ft, approximately 94 percent of the littoral marsh is dry and no longer functions as habitat for fish and other aquatic-dependent wildlife (District 2000a). Also, the spread of invasive species such as torpedo grass and *Melaleuca* is facilitated by long periods of dry littoral marsh. The western littoral zone of Lake Okeechobee is important habitat for the Everglade snail kite, and is designated as critical habitat. Apple snails within the littoral zone can tolerate dry-outs of short duration outside of their peak breeding season (April-May), but extremely low water levels for long durations, particularly during their breeding season, will heavily impact the snail population (Darby et al. 2003; 2004), and therefore affect the nesting efforts of the snail kite.

The MFL for Lake Okeechobee is currently defined as:

> The water level in the lake should not fall below 11 ft for more than 80 days duration, more often than once every 6 years, on average (District 2000a).

The Service believes that this definition is a good estimate of what would constitute significant harm to the ecological integrity of the lake. While we do not focus on single species management, the importance of maintaining a healthy apple snail population is critical for ensuring the suitability of the snail kite's critical habitat within Lake Okeechobee. This MFL target can act as a surrogate measure of the lake's suitability for apple snail habitat, in addition to other ecological concerns.

3. Effects of Lake Stage on Water Quality in the Lake

Havens (1997) provides a review of ecological changes in Lake Okeechobee caused by cultural eutrophication and discusses the relationships between higher lake stages and increased total phosphorus concentrations in the pelagic zone of the lake. Janus et al. (1990) and Maceina (1993) hypothesize that higher lake stages increase the incidence of algal blooms. An algal bloom in August 1986, covering 300 km^2, caused the death of thousands of apple snails in the western littoral zone of the lake, part of the designated critical habitat for the endangered snail kite, which feeds almost exclusively on apple snails.

The concentration of total phosphorus in the lake nearly doubled from 49 parts per billion (ppb) in 1973 to 98 ppb in 1984 (Janus et al. 1990). Despite progress in reducing phosphorus loading rates to the lake through implementation of Best Management Practices in dairies north of the lake, the phosphorus loading exceeds the legally-mandated Surface Water Improvement and Management plan target. The Lake Okeechobee Protection Act provides substantial cost sharing incentives to farmers within the Kissimmee basin, and since 2002, many water quality improvement projects have been implemented within the Lake Okeechobee watershed.

The water column phosphorus concentration goal for the lake is 40 ppb. At present, the concentration of phosphorus in the lake averages 214 ppb, with an average of 158 ppb over the past five years (District 2006b), partly due to the high inputs from lake sediments, but mostly from re-suspension of lake sediment from the hurricanes in 2004 and 2005 that has yet to settle

out. Even with reduction of phosphorus loading from external sources, internal phosphorus loading from re-suspension of phosphorus-rich sediments that have built up in the lake may affect water quality in the lake for several decades (Havens et al. 1996a; Steinman et al. 1998). The result from the four hurricanes in 2004 was a total volume of inflows and rainfall to the lake for the 3 months (August–October 2004) of 3.2 million acre-feet (af), which is close to an average water year in total volume inflow. This large inflow resulted in high loads of phosphorus, with approximately 792 metric tons of phosphorus added in these 3 months alone (District 2006a).

Warren et al. (1995) found that the benthic invertebrate communities of Lake Okeechobee's sublittoral zone are of relatively poor quality and that shifts toward dominance of more undesirable species (indicative of highly eutrophic conditions) have occurred at a rapid rate. Higher lake stages are likely to increase the transport of nutrient-rich water from the pelagic zone to the littoral zone, which would ultimately reduce the diversity of the invertebrate community in the littoral zone, which has a higher diversity of benthic invertebrates than the sublittoral zone (Havens et al. 1996b).

Havens and James (1999) suggest that observed declines in water transparency could be explained by the migration of mud sediments from mid-lake towards the littoral zone along the southwestern shore. This migration of sediment would be more likely to occur under extended periods of high water and could have severe impact on the primary productivity of the littoral zone. The reduction in water clarity, which is more likely to occur with a combination of high average water stages and storms, can have an adverse effect not only on SAV, but also the extremely important periphyton community. Similar to the Everglades, a healthy littoral zone in Lake Okeechobee sustains periphyton, which is a nutritious food base for grazing invertebrates and fishes, such as grass shrimp (*Palaemonetes paludosus*), apple snails, flagfish (*Jordanella floridae*), and sailfin mollies (*Poecilia latipinna*). These fish and invertebrates rely on the primary production of periphyton and form a key linkage in the food chain to commercially and recreationally important fish and wildlife. In addition to loss of bulrush stems on the outer edge of the littoral zone during the extended high water event of 1994 to 1995, since that time, the remaining bulrush has been largely lacking periphyton (Fox 2007), apparently because of a combination of physical scouring of the stems and the lack of light penetration, both of which can be correlated with high water levels. The increased turbidity following the 2004 and 2005 hurricanes has also apparently retarded regrowth of periphyton on the stems of emergent vegetation that survived physical damage from the storms.

4. Spread of Exotic Vegetation in the Littoral Zone

The conceptual ecological model for Lake Okeechobee indicates that extremely low water stages may favor expansion of exotic vegetation. The Service finds that although water regulation certainly is one of several variables influencing spread of exotic vegetation, the magnitude of this variable relative to others has not been clearly documented.

The spike rush habitat in Moonshine Bay (preferred foraging habitat for the snail kite) is encircled by the exotic torpedo grass, which may overtake the region if low water levels suppress

the growth and survival of the native plants. Torpedo grass is tolerant of a much wider range of hydroperiods, and appears to thrive under both wet and dry conditions (Sutton 1996). Torpedo grass is poor habitat and cannot support the fish and wildlife populations that are found in native vegetation. However, Smith et al. (1995) suggest that once every several years, allowing the lake stage to drop to 10 to 12 ft in the dry season would be beneficial to wading bird populations, "to expose prey-rich submerged beds, invigorate essential willow stands, and to allow fires to burn away cattail and *Panicum* wrack, recycle nutrients, and encourage establishment of attractive successional vegetation complexes." The current set of performance measures produce unfavorable scores when lake stages drop below 11 ft. The Service would not agree at this time with Smith et al. (1995) regarding the recommendation to drop water levels below 11 ft on a regular basis, but we would encourage controlled burning in the littoral zone whenever natural droughts allow it. Research is needed to determine the consequences of such a management policy relative to expansion of exotic vegetation and overall diversity and productivity of the littoral zone.

Smith et al. (1995) state that *Melaleuca* expanded its range in Lake Okeechobee following the 1989-90 drought, displacing some areas of more productive spike rush and beak rush (*Rhynchospora*) flats. However, based on experiments in mesocosms subjected to varied hydroperiods, Lockhart et al. (1999) found that a lower lake regulation schedule may not stimulate expansion of *Melaleuca*. They found that although *Melaleuca* is affected by hydroperiod, it is highly adaptable to a wide range of environmental conditions, and that water management is not the most effective management alternative to control this exotic species. They recommend continuation of the ongoing chemical treatment of *Melaleuca*, with introduction of biological controls, as a more effective management strategy.

5. Effects of the Lake Okeechobee Regulation Schedule on the St. Lucie and Caloosahatchee Estuaries

The Lake Okeechobee regulation schedule can have a direct effect on estuarine health due to the relationship between regulatory lake releases and the salinity within the estuaries. Maintaining the desired salinity within the estuaries is a delicate balance, with seasonal and historical fluctuations that support a wide range of salt-tolerant plant and animal communities. During the dry season, freshwater flow to the estuaries is reduced, or even eliminated, which results in a rise in salinity within the estuarine systems. For the St. Lucie estuary, local basin runoff is enough to maintain minimal freshwater input into the estuary, except in the driest years, but the Caloosahatchee estuary depends on fresh water releases from Lake Okeechobee to maintain a healthy ecosystem during the dry season, particularly during drought conditions. Conversely, during the wet season, excessive flows of fresh water from the lake to the estuaries lower the salinity within the estuaries to damaging, and sometimes destructive, levels. Current performance measures use freshwater flow volumes as a surrogate measure for desirable salinity conditions within the estuaries. Future revisions of the regulation schedule should also include evaluation of nutrient (phosphorus and nitrogen) concentrations and loading to the estuaries.

Caloosahatchee Estuary

Major environmental concerns for the Caloosahatchee estuary and San Carlos Bay include altered fresh water inflows, extreme variation in salinity levels, and eutrophication, all of which can be attributed to excessive releases of fresh water flows from Lake Okeechobee and runoff from the Caloosahatchee River drainage basin. The river has undergone a number of hydrological modifications, often without regard to the health of the estuarine community (Haunert et al. 2000), to facilitate navigation, flood control, and lake regulatory releases. Such modifications have dramatically altered the natural quantity, quality, timing, and distribution of freshwater flows to the estuary and created extreme fluctuations in salinity levels.

The Caloosahatchee River was originally a shallow, meandering river with headwaters in the proximity of Lake Flirt (Kimes and Crocker 1998) and probably only rarely received water from outside its watershed or from Lake Okeechobee except during extreme regional flooding events. The river was connected to Lake Okeechobee in 1881 as an attempt to lower the lake's water table. The river now functions as a primary canal (C-43) that serves as a major outlet for regulatory releases from Lake Okeechobee to the Gulf of Mexico, and drains an area of about 1,327 square miles. Wet season runoff that was historically retained within the undeveloped Caloosahatchee watershed now reaches the river in greater volume and less time through an intricate canal system (Corps 1957) and is often compounded by lake releases.

Three locks and dams were constructed to control flow and stage height in the river. The most downstream structure, the W.P. Franklin Lock and Dam (S-79), marks the beginning of the Caloosahatchee Estuary. The S-79 structure maintains specific water levels upstream, regulates freshwater discharge into the estuary, and acts as an impediment to saltwater intrusion and tidal action which historically extended far upstream. Thus, S-79 truncates the estuary and now spatially limits the dry season oligohaline (*i.e.,* freshwater and low salinity brackish water) zone of the estuary, as well as the free passage of organisms seeking refuge, nursery, and breeding areas characteristic of this zone (Chamberlain and Doering 1998a, 1998b; Doering et al. 2002; District 2002).

The natural and historic gradient of salinity zones within the Caloosahatchee Estuary and San Carlos Bay serve as important nursery, feeding, and refugia areas for juvenile stages of desirable sport and commercial fishes. At least 70 percent of Florida's recreationally sought fishes depend on estuaries for at least part of their life histories (Harris et al. 1983; Estevez 1998; Lindall 1973). Excessive variation in fresh water flows and salinity maintain estuarine biota in a constant flux between those favoring higher salinity and those favoring lower salinity (Bulger et al. 1990). Optimal salinity conditions may not last long enough for organisms to complete their life cycle and the estuary can become devoid of some populations, even keystone species that support major ecosystem components along an estuary's salinity gradient such as fresh and salt water SAV and/or oysters.

Depending on day of the year, the long-term mean daily discharge at S-79 ranges between 300 cubic feet per second (cfs) and 3,000 cfs. However, daily and monthly inflows often exceed this long-term average particularly during the wet season, with prolonged inflows commonly exceeding 4,500 cfs lowering salinity levels in the San Carlos Bay area and the J.N. "Ding"

Darling National Wildlife Refuge (NWR). Flows that reach above this threshold (occasionally exceeding 10,000 cfs) can push freshwater into Pine Island Sound and the Gulf of Mexico, thus impacting ecologically and commercially important high-salinity marine resources that historically were not directly affected by Caloosahatchee River discharges. During the dry season, the combination of limited rainfall, lack of water storage in the basin and withdrawals to meet human demands for irrigation and potable water often results in periods of no freshwater discharge to the estuary. Saltwater can intrude all the way upstream to S-79 threatening species that require low salinity to complete their life cycle (Chamberlain and Doering 1998a, 1998b; Doering et al. 2002; District 2002).

Tape grass (*Vallisneria americana*) is the dominant SAV in the upper Caloosahatchee estuary including the 40-acre Caloosahatchee NWR and occurs in well-defined beds in shallow water. Tapegrass is an important habitat for a variety of freshwater and estuarine invertebrate and vertebrate species, including some commercially and recreationally important fishes (Bortone and Turpin 1999) and migratory waterfowl. During times of extended low inflow conditions, when salinity is too high, tape grass becomes very sparse and can disappear completely (Chamberlain et al. 1995; Doering et al. 2002; District 2000b). Preliminary analysis suggests that a minimum inflow of 300 cfs during the dry season will promote the growth of *Vallisneria americana*.

A substantial loss in the extent of seagrass coverage has occurred in the lower estuary (Harris et al. 1983). Each species of SAV has a specific temperature and salinity tolerance range and their tolerance towards variations in salinity are similar to their tolerances for temperature. Furthermore, estuarine biota is well adapted to and depends upon natural seasonal changes in salinity. When salinity falls outside of these normal and seasonal ranges, it may result in a reduction in densities and shifts in distribution of SAV species and organisms dependant upon these productive habitats (Chamberlain and Doering 1998b).

Shoal grass (*Halodule wrightii*) is the only seagrass species consistently located in the lower estuary upstream of Shell Point until it mixes downstream with turtle grass (*Thalassia testudinum*) in San Carlos Bay. Although shoal grass has a wide salinity tolerance (McMahan 1968), high freshwater inflows (*i.e.,* greater than 3,000 cfs) from S-79 influence its distribution and density (Chamberlain and Doering 1998b; Doering et al. 2002). Shoal grass tolerates salinity as high as 44 parts per thousand (ppt); its' productivity decreases when salinity falls below 20 ppt; and it does not survive when salinity drops below 3.5 ppt for extend periods (*i.e.,* 30 days or more) (Zieman and Zieman 1989). This wide tolerance is probably why it is the only true seagrass species encountered upstream of Shell Point where salinity is lower and more variable than in San Carlos Bay (Chamberlain et al 1995; Chamberlain and Doering 1998b; Doering et al. 2002). Accordingly, shoal grass biomass is lower above Shell Point than in downstream areas where salinity is above 20 ppt more consistently.

Turtle grass does not grow in areas with salinity normally below 17 ppt and will suffer significant leaf loss when exposed to lower salinity. The maximum productivity of turtle grass occurs in full strength seawater and decreases proportionately with decreasing salinity.

Optimum salinity range for turtle grass is ranges from 24 to 35 ppt (Zieman and Zieman 1989). Thus, turtle grass does not exist upstream of Shell Point where salinity is more variable.

Extremely high fresh water flows to the Caloosahatchee estuary occurred for extended time periods during the 2004 and 2005 hurricane seasons causing a reduction in density and cover of seagrass beds in the estuary, extending into San Carlos Bay and the J.N. "Ding" Darling NWR. Additionally, lake releases carried high nutrient levels from bottom sediments that were re-suspended by the hurricanes. Harmful algal blooms occurred in the Caloosahatchee River and estuary following periods of high regulatory releases from Lake Okeechobee causing public concern, and this was cited as one of the impacts that led the American Rivers organization to list the Caloosahatchee among the top 10 endangered rivers in the United States (American Rivers 2006).

Salinity is also important in determining the distribution of coastal and estuarine bivalves, such as oysters. Short pulses of freshwater inflow can greatly benefit oyster populations by killing predators, while excessive freshwater inflows may kill entire populations of oysters (Gunter 1953; Schlesselman 1955; MacKenzie 1977). Although a substantial oyster population still exists within the lower Caloosahatchee Estuary, historical accounts of the river indicate that oysters were once a more prominent feature in the area upstream (Sackett 1888). As individual oysters die they leave empty compartments for various estuarine residents. Volety et al. (2003) found that a greater abundance of decapods and fishes were associated with clusters of live oysters compared to dead-articulated clusters, while the structure provided by both living and dead oyster shells supported a greater abundance of these estuarine organisms than no shells at all.

Oysters in southwest Florida spawn continuously, with peak recruitment (spat settlement) occurring during May to November. Recruitment at these times is often threatened by large freshwater inflows through S-79 (*i.e.,* greater than 4,000), a portion of which can be attributed to the need to regulate Lake Okeechobee. These freshwater flows expose oyster larvae to lethally low salinities (*i.e.,* 5 ppt or less), or flush the larvae to more downstream locations where there may not be suitable substrate for settlement (Volety et al. 2003).

The District conducted research in the Caloosahatchee Estuary focusing on the impacts associated with the extreme variability in freshwater inflow from S-79 (Chamberlain and Doering 1998a). The purpose of the research was to determine the proper timing and volume of water quantity required to support valued ecosystem components, including submerged freshwater and marine grasses and oysters, as well as the impacts of flows on general biotic indicators, such as fish, plankton and benthic invertebrates (District 1998). This research resulted in the development of optimum S-79 flow ranges and delivery patterns for the estuary (Chamberlain and Doering 1998b; Doering et al. 2002; Volety et al. 2003). The information has formed the basis for development of hydrologic performance measures to evaluate alternatives for this study, the Comprehensive Everglades Restoration Plan, and the Southwest Florida Feasibility Study, as well as meeting legislative mandates for the development of salinity criteria for the establishment of the Caloosahatchee River and Estuary MFL (District 2000b, 2003).

The MFL salinity criteria were initially designed to protect tape grass upstream of Ft. Myers but are also beneficial for other organisms that utilize this low salinity region of the estuary (Chamberlain and Doering 1998b; Doering et al 2002). The MFL study indicated that the proposed criteria for the Caloosahatchee River and Estuary will be exceeded on a regular and continuing basis until additional storage is provided in the basin to supply the additional water needed. Although the currently proposed changes to the regulation schedule do not include additional water storage in the system, the study team attempted to increase the period of time in which the MFL criterion could be met.

These criteria and performance measures were derived from relationships between the distribution, abundance, growth and survival of estuarine organisms and changes in salinity or freshwater discharge. Salinity tolerances of submerged grasses were initially used to identify minimum and maximum inflows at S-79. Mean monthly flows less than 300 cfs are thought to allow salinity in the upper estuary to exceed the tolerance of tape grass. Flows greater than 2,800 cfs depress salinity in the lower estuary and threatens the marine shoal grass typical of this region (Chamberlain and Doering 1998b; Doering et al. 2002). Research has shown that flows at S-79 within this range are beneficial to other estuarine organisms (*i.e.,* anchovy, perch, snook, redfish, zooplankton, ichthyoplankton, shrimp, crab, oysters, and benthic invertebrates) as well, and that flows greater than 2,800 cfs may also be detrimental to those biota (Chamberlain and Doering 1998a, 1998b; District 2003; Volety et al. 2003). Therefore, a distribution of inflows that range from 300 to 1,500 cfs, with a peak of 300 to 800 cfs, should be generally beneficial to the biota of the estuary (Chamberlain and Doering 1998a, 1998b; District 2003).

St. Lucie Estuary

The ecological problems within the St. Lucie estuary are very similar to those experienced by the Caloosahatchee in terms of damage to estuarine plant and animal communities. Ecological harm from high flows to the St. Lucie estuary during the 1997-1998 winter-spring El Niño event and during the 2004-2005 hurricane seasons caused serious public concern. The North Fork of the St. Lucie River, which normally averages 18 ppt salinity decreased to 0 ppt during peak flows. Portions of the St. Lucie estuary that normally average 24 ppt decreased to 5 ppt, and the Indian River Lagoon, which normally averages 30 ppt, decreased to approximately 20 ppt. The high volume freshwater discharges coincided with a high incidence of fish with lesions and public health warnings.

In addition to the deleterious effect that freshwater releases from Lake Okeechobee has on salinity, direct impacts on the water quality of the estuary are felt, including conveyance of silts, sediments and other pollutants to the estuary. Because of local runoff from agricultural and urban development within the watershed, even in the absence of Lake Okeechobee discharges, the desirable salinity envelope of the estuary is often violated by too much fresh water entering the estuary.

6. Effects of the Lake Okeechobee Regulation Schedule on the Arthur R. Marshall Loxahatchee National Wildlife Refuge

Water Conservation Area 1 (WCA-1) operates on state-owned land managed by the Service under a license agreement with the state of Florida as the Arthur R. Marshal Loxahatchee National Wildlife Refuge (A.R.M. Loxahatchee NWR). WCA-1 has three primary uses: flood protection, water supply (to the Lake Worth Drainage District, and also Broward and Palm Beach Counties), and the natural environment. Water elevations within WCA-1 are governed by a regulation schedule similar to that used for Lake Okeechobee. Ground level elevations within WCA-1 range from 17 ft at the northern end to 12 ft at the southern end. The current operational minimum water level as described by the regulation schedule (Corps 1995) is 14 ft within the perimeter canal.

When the water level within WCA-1 is in Zone B of its regulation schedule, water supply releases are not permitted unless an equal amount of water is first supplied to WCA-1 from Lake Okeechobee as preemptive replacement water. This replacement water can be supplied to WCA-1 only when the water elevation within Lake Okeechobee is no more than 1.0 ft lower than the water elevation in WCA-1. Water supply withdrawals can continue until the water elevation within WCA-1 drops below 14 ft. At that point, temporary deviations from the regulation schedule may be approved to allow water supply withdrawals to continue below the 14 ft elevation. If the water elevation within Lake Okeechobee is more than 1.0 ft lower than the water elevation in WCA-1, then it is no longer required that replacement water be released from the lake to WCA-1, and all further water supply withdrawals therefore constitute a net loss of water to WCA-1.

Managing Lake Okeechobee at lower levels may reduce preceding inflow events to WCA-1 because of an increased likelihood of the difference between the lake and WCA-1 stages being greater than 1 ft. As a result, reducing the number of preceding inflow events to WCA-1 may translate into drier conditions with WCA-1 and also increase the likelihood of deviation requests by water users to go below the 14 ft floor for water supply purposes.

Overall, lower water levels within Lake Okeechobee have the potential of exacerbating stressful ecological conditions within WCA-1 during the dry season. Chronic and frequent events below the 14 ft floor may:

- Increase the expansion of invasive species;
- Facilitate the undesirable conversion of slough and wet prairie habitats to sawgrass and shrub habitats;
- Decrease habitat suitability for fish populations;
- Potentially reduce nesting and foraging options for wading bird populations;
- Increase the likelihood of severe wildland/muck fires; and
- Influence how the marsh responds to re-wetting events when stage and/or rainfall increases during the beginning of the rainy season.

C. Summary/Planning Objectives

With a wide variety of resource concerns dependent upon the effectiveness of the lake's regulation schedule, the planning objective for this project was to balance these resource needs against one another, and select a plan that best meets the goal of the project. As mentioned earlier in this report, the Corps altered the emphasis of its planning objectives, favoring flood protection (integrity of the HHD) over the originally stated environmental improvement objectives. Consequently, when considering the proposed alternatives, more weight was given to maximizing the flood control capacity of the lake. The PDT collectively evaluated the environmental benefits of each alternative within this constraint.

V. EVALUATION METHODOLOGY

Experts on Lake Okeechobee operations and the South Florida Water Management Model (SFWMM) began the development of alternative plans for evaluation by the PDT in early 2006. The SFWMM was designed to simulate the hydrology and management of south Florida water resources from Lake Okeechobee south to Florida Bay. Model output was run through performance measures resulting in large amounts of comparative data for evaluation by the PDT. Throughout the evaluation process, many of the alternatives were modified to improve their performance and to account for changes in model assumptions, resulting in several tiers of alternatives. When evaluating each tier of alternatives, the agencies formed a consensus on which alternatives were worthy of further modification and evaluation, and which ones were to be dropped due to their failure to meet project goals and expectations.

Evaluations of the alternatives were made by comparing the modeling results for each alternative (as expressed in performance measure output) with the No Action alternative (2007LORS), and with each other. Those alternatives that performed far outside the range of the other alternatives, or which violated performance constraints were modified to improve their performance, or eliminated from further review. Throughout most of the review period, team consensus was achieved to select which alternatives moved forward in the review process, though certain alternatives were carried through the evaluation to provide a broader array of alternatives to be considered for the National Environmental Policy Act evaluation (*e.g.*, Alternative 3).

When providing our input for the PDT review, the Service evaluated the alternatives using the following performance measures:

Caloosahatchee Estuary

- Number of Mean Monthly Flows <450 cfs
- Number of Mean Monthly Flows between 2,800 and 4,500 cfs
- Number of Mean Monthly Flows >2,800 cfs (from basin)
- Number of Mean Monthly Flows >2,800 cfs (from Lake Okeechobee)
- Number of Mean Monthly Flows >2,800 cfs (total)
- Number of Mean Monthly Flows >4,500 cfs
- Number of Mean Monthly Flows >4,500 cfs for >5 weeks
- Number of Mean Monthly Flows >4,500 cfs for >12 weeks *

St. Lucie Estuary

- Number of Mean Monthly Flows <350 cfs
- Number of Mean Bi-weekly Flows >2,000 cfs (from basin)
- Number of Mean Bi-weekly Flows >2,000 cfs (from Lake Okeechobee)
- Number of Mean Bi-weekly Flows >2,000 cfs (total)
- Number of Mean Monthly Flows between 2,000 and 3,000 cfs
- Number of Mean Monthly Flows >2,000 cfs
- Number of Mean Monthly Flows >3,000 cfs
- Number of Mean Moving 2-Week Flows >3,000 cfs for > 2 weeks *

Lake Okeechobee

- Low Stage < 11 ft
- Low Stage < 11 ft for > 80 days
- Low Stage < 12 ft for > 365 days
- Low Stage Number of Days < 12.56 ft
- High Stage > 15 ft for > 365 days
- High Stage > 17 ft
- High Stage > 17.25 ft for > 7 days *
- High Stage > 17.5 ft for > 7 days

* = used only in evaluations of the final set of alternatives

Additional performance measures were used by other PDT member agencies in their respective evaluations, and were discussed and considered during regular PDT meetings. The District conducted detailed evaluations of water supply, estuaries, Lake Okeechobee ecology, and the greater Everglades ecosystem. The Corps focused primarily on certain issues, specifically, flood control, integrity of the HHD, and navigation.

Because the Service is primarily concerned with the ecological effects of the project, we looked closely at the Everglades evaluation performed by the District. They analyzed the performance measure output for peat dry-out, reversals, recessions, tree island inundation, and snail kites within the WCAs. All of these performance measures used model output from a representative sample of CERP Indicator Regions from WCA-1 (A.R.M. Loxahatchee NWR), throughout WCA-2 and WCA-3, and south to Shark River Slough in ENP.

VI. FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT

Without selection and implementation of the proposed TSP (Alt-T3), the current WSE regulation schedule would be maintained for 3 more years, until a new revision to the schedule is implemented in 2010. None of the final tier of alternatives evaluated for the project would be expected to improve performance across the full range of performance measures, even if we limit consideration to ecological performance measures, excluding flood control and water supply concerns. The TSP is the only alternative that strikes a more acceptable balance in

environmental trade-offs than the existing WSE schedule. Under the present regulatory constraints, extreme high and low water stages, as have occurred over the past 6 years, cannot be entirely prevented regardless of which alternative is selected. The damages to the St. Lucie and Caloosahatchee estuaries and to Lake Okeechobee's littoral zone from high water events would likely be of slightly greater amplitude and/or duration with continuation of the WSE schedule, as compared to the TSP. However, impacts to Lake Okeechobee from low water events (such as drought) would likely be less with the No Action alternative than with the TSP. On balance, we believe that the TSP is the only alternative that is generally better than the No Action alternative in most of the resource areas of concern. The No Action alternative might be more favorable overall if the next 3 years include a severe or prolonged drought. However, the interest in lowering the potential risks of high water on the HHD is a strong motivation, and will be seen as the correct course if the next 3 years have higher than average precipitation. With years of high precipitation, the overall ecological benefits of reducing the duration and magnitude of high water stages would not be realized under the No Action alternative.

VII. DESCRIPTION OF SELECTED PLAN AND OTHER ALTERNATIVES

A. Selected Plan

The Corps has chosen Alternative T3 (also known as Alt1bS2-T3 or Alt-T3) as the TSP in the revised draft of the SEIS. The TSP for the initial draft of the SEIS, which was released for public review on August 10, 2006, presented Alt1bS2-m as the TSP. Due to large volume of negative feedback from the public regarding the poor performance of Alt1bS2-m, the Corps decided to reformulate the TSP in order to improve its performance, particularly with respect to high freshwater flows to the Caloosahatchee estuary. The final tier of alternatives was subjected to an additional round of modeling and new evaluations, with the opportunity to achieve additional refinement in an iterative process. From these final alternatives, Alternative T3 was chosen as the new TSP.

Because this alternative is a derivative of earlier, competing alternatives, a stand-alone description of it would be difficult to comprehend without putting it into context of the overall linear development of the *Alt1b* series of alternatives. Consequently, refer to the following section for descriptions of all the alternatives, including the TSP.

B. Tiers of Alternatives

The project began with consideration of four basic alternatives: Alternative (Alt)1, Alt2, Alt3, and the No Action alternative (which is known as 2007LORS, or the future without project condition). After preliminary discussions between modelers, these alternatives were modified, and both Alt1 and Alt2 were split into two new versions, called Alt1a, Alt1b, Alt2a and Alt2b. These four, along with Alt3 and 2007LORS, comprised the initial tier of alternatives evaluated by the PDT.

The second tier of alternatives was composed of further modifications to Alternatives 1a, 1b and 2b, plus the addition of a fourth alternative called Alt4. Alt3 was dropped from further

consideration because of poor performance, and this resulted in the following group of alternatives: Alt1aS1, Alt1aS2, Alt1bS1, Alt1bS2, Alt2a, Alt2b, Alt2bS1, Alt4 and 2007LORS.

After reviewing this alternative group, the decision was made to move only three of the proposed alternatives forward in the review process (in addition to the 2007LORS No Action alternative), and the PDT reached a consensus to select Alt1aS2, Alt1bS2 and Alt4 as the three final alternatives. Alt2a was added to this final tier at the insistence of the Corps, and Alt3 was also later added to the final tier, in deference to earlier public comments. This group was to be the final tier of evaluations prior to publication of the Draft SEIS, and selection of the TSP.

During the modeling and evaluation process for this tier of alternatives, further enhancements and constraints were imposed upon the alternatives, which went through several more iterations (known as sensitivity runs), and resulted in the following alternatives being evaluated by the Corps in their Draft SEIS: Alt1bS2-A, Alt1bS2-m, Alt2a-B, Alt2a-m, Alt4-A and 2007LORS. The Corps then solicited input from PDT members, and chose Alt1bS2-m as the TSP.

After publication of the Draft SEIS, the large volume of negative public comments on the proposed TSP prompted the Corps and the PDT to reformulate the TSP and evaluate a new set of alternatives. The new set of alternatives were all derived from Alt1bS2-A, and throughout this report are referred to as the final tier of alternatives. Please refer to Figure 2 for the lineage of the final array of alternatives.

C. Alternative Descriptions

The goal of this project is to revise the regulation schedule for the operation of an existing infrastructure of water conveyance and control structures, and no new construction is proposed. Each alternative is a variation of operational rules to determine when, where, and how much water should be released from the lake to downstream systems. Alternatives can be depicted by charts and decision trees, and describing them in a textual form is difficult. The following alternative descriptions are taken from the website maintained by the Corps for dissemination of information and modeling data related to this project (http://hpm.sfrestore.org/loweb/sfwmm/). For the most part the descriptions here are repeated verbatim from the Corps' website, with minor editorial changes made to remove extraneous information and improve readability. Please refer to referenced website, and to the Draft SEIS (Corps 2006) for further information on the development and refinement of the alternatives.

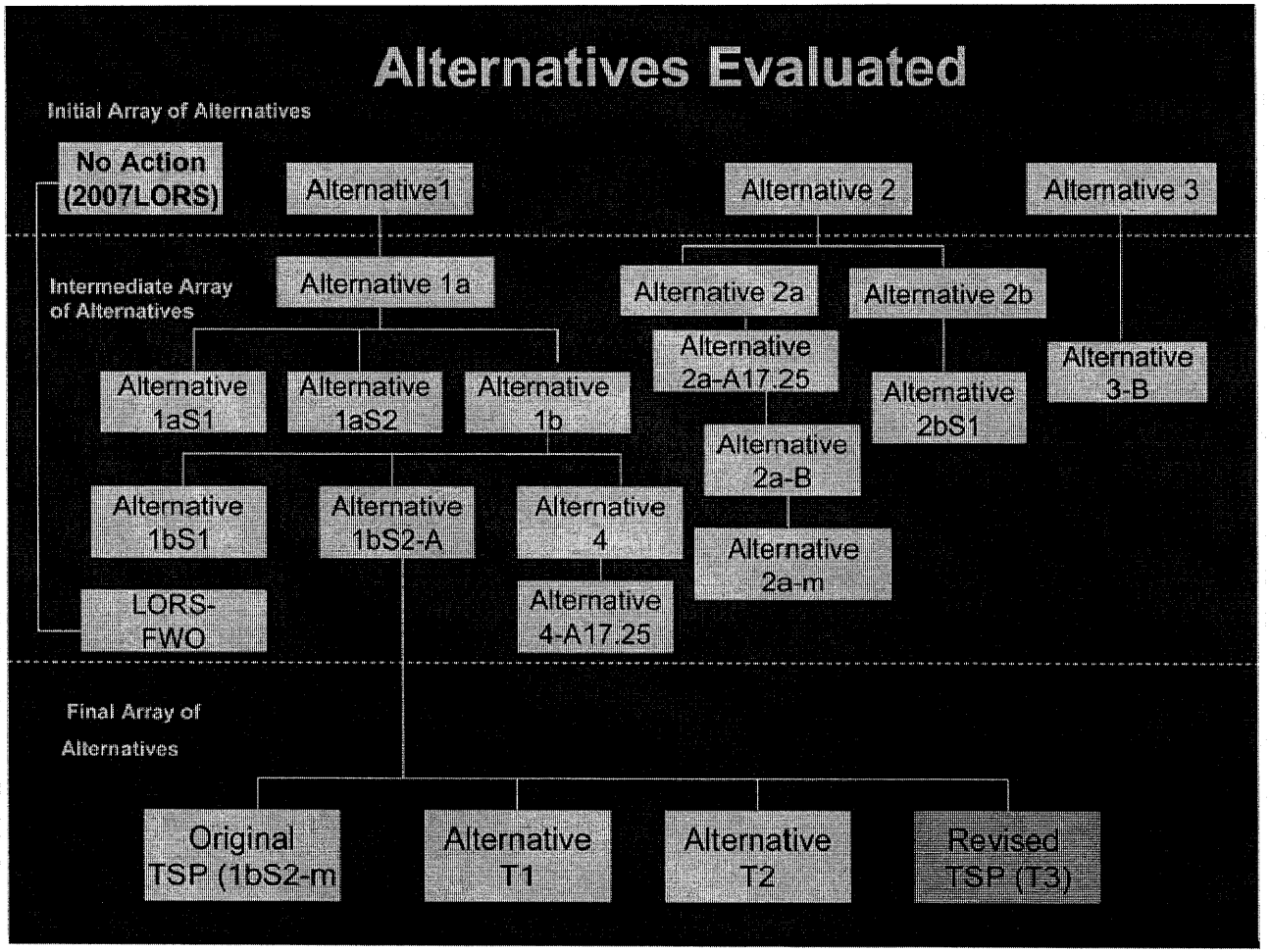

Figure 2. Final array of alternatives.

1. LORS Base Runs

The following describes the origin and evolution of the 2007LORS existing condition model run, as developed from the District modeling of the 2005 Lower East Coast Regional Water Supply Plan (LECRWSP).

2005BS
This is the input from the District for the Lower East Coast (LEC)2005 base case (2005 LECRWSP).

2005LORS
This run was created from the above run with changes that better represent the Interim Operational Plan (IOP) operations. Based on modeling conference calls on February 6, 10, and 16, 2005, between Corps modelers and District modeling staff, it was agreed that the LECRWSP 2005 input files would need to be modified to include IOP operations, as modeled with the 'Alt7r5' model run developed by the Corps for the Combined Structural and Operational Plan (CSOP) project. It was recognized that changes were likely not completed due to parallel track of CSOP 'Alt7r5' modeling and LECRWSP 2005 modeling.

2006LORS
This run was created from 2005LORS, but includes a canal capacity restriction in the EAA canals to mimic the maximum desired flows from Lake Okeechobee to STA 3/4. Annual total treatment capacity is 63,179 acre-feet (af).

2007LORS
This run was created from 2006LORS, but includes the operation of the temporary forward pumps for EAA water supply from Lake Okeechobee during dry times. Consistent with 2005LORS and 2006LORS, water supply deliveries to EAA are allowed during times of LEC demands for all days of the week. 2007LORS is a model representation of the future without project condition for the LORS alternative evaluation process.

2. Preliminary LORS Alternatives, General Overview

Eleven preliminary alternatives were formulated, refined, and evaluated by the LORS PDT during the time period of January through March of 2006. The features of these 11 alternatives are summarized in this section of the report; additional graphics to illustrate the proposed regulation schedules and operational decision guidelines are available in a presentation under the 'alternative overview' link on the LORS webpage (http://hpm.sfrestore.org/loweb/sfwmm/). The last tier of these preliminary alternatives was included in the evaluation presented to the public in the first draft of the SEIS, and the original TSP (Alt1bS2-m) was selected from this set of alternatives.

a. General Assumptions

1) Average annual deliveries to STA-3/4 may not exceed treatment capacity:
   - Identified by District (February 2006) based on current nutrient levels in Lake Okeechobee;
   - 58,457 af (wet season); 4,722 af (dry season).

2) Supply Side Management (SSM) line lowered by 1.0 feet from current District line:
   - District recommendation as surrogate for 2006 SSM study, to be completed following selection of the LORS TSP;
   - Base condition (2007LORS) for alternative comparisons assumes current SSM line to remain in place.

3) All alternatives were developed from the 2007LORS alternative and include temporary forward pumps capable of pumping at the following capacities:
   - 600 cfs at S-351 (Hillsboro, North New River canals);
   - 400 cfs at S-352 (West Palm Beach Canal);
   - 400 cfs at S-354 (Miami Canal).

4) Backflow from St. Lucie canal to Lake Okeechobee is allowed at lake stages of 14.50 feet or 0.25 feet below the bottom of the lowest non-base flow regulatory zone, whichever is lower:
   - Operations developed to achieve similar performance to 2007LORS, while seeking to avoid frequent oscillation between regulatory releases and backflow releases at S-308;
   - Base condition (2007LORS) assumes backflow below 14.50 feet, which is always more than 0.25 feet below the lowest regulatory release zone (Zone D) under WSE;
   - Lowest non-base flow zone defined as follows: for Alt1a, Alt1aS1, Alt1aS2, Alt1b, Alt1bS1, Alt1bS2, Alt2b and Alt4, Zone D1; for Alt2a, cyan zone; for Alt3 Zone D

b. Alternative Overview

ALTERNATIVE 1A

This alternative was developed from the current WSE decision tree structure, with the following changes:

- The reshaping of the line representing the divide between Zone D and Zone E;
- Applying tributary hydrologic conditions that represent longer term wet or dry conditions that have persisted in the tributaries;
- Allow Base flow when Lake Okeechobee water levels are in Zone D0 or above, but no base flow releases when the stage falls below the bottom of Zone D (Zone D0).

ALTERNATIVE 1AS1

This alternative was developed from Alternative 1a. Alternative 1aS1 provides increased opportunity for base flow releases to the estuaries by lowering the bottom of Zone D0 by 0.5 feet.

ALTERNATIVE 1AS2

This alternative was developed from Alternative 1a. Alternative 1aS2 provides increased opportunity for base flow releases to the estuaries by lowering the bottom of Zone D0 by 1.0 feet.

ALTERNATIVE 1B

This alternative was developed from Alternative 1a, with the following changes:

- The bottom of regulatory zones A, B, and C are lowered, resulting in a more pro-active schedule to limit high water conditions in Lake Okeechobee;
- Reduced moderate to extreme high discharges to St. Lucie Estuary with modified discharge rates: Zone B maximum discharge at S-80 lowered from 3500 to 2800 cfs; and Zone C maximum discharge at S-80 lowered from 2500 to 1800 cfs.

ALTERNATIVE 1BS1

This alternative was developed from Alternative 1b. Alternative 1bS1 provides increased opportunity for base flow releases to the estuaries by lowering the bottom of Zone D0 by 0.5 feet (similar approach as alternative 1aS1).

ALTERNATIVE 1BS2

This alternative was developed from Alternative 1b. Alternative 1bS2 provides increased opportunity for base flow releases to the estuaries by lowering the bottom of Zone D0 by 1.0 feet (similar approach as alternative 1aS2).

ALTERNATIVE 2A

This alternative represents a new approach to the regulation schedule for Lake Okeechobee, developed from analysis of 1965-2005 data, with updated release guidelines:

- POR releases from S-77 and S-308 were added back to Lake Okeechobee historical elevation to develop simulated lake Okeechobee elevation with no releases made thru S-77 and S-308
- Probabilities for the rate of change in Lake Okeechobee with no releases to S-77 and S-308 were defined and summarized for 30, 60, and 90 day forecasting periods;
- Lake stage criteria for the upper 2 regulation guideline paths are defined based on a 50percent and 25 percent probability of the lake stage reaching 17.5 feet within 90 days, with the operational intent to recognize the COE-defined maximum elevation for Lake Okeechobee due to HHD as 17.5 ft;
- Tributary conditions evaluated using Palmer Drought Index and 2-week total Lake O. inflows, as used in alternatives 1a and 1b;
- Base flow zone is defined to target maintenance of lake stages above 12.56 navigation constraint stage and always above 2007LORS supply side management line;
- Regulatory releases from Lake Okeechobee to the Water Conservation Areas are discontinued for lake stage below 13.50 feet;
- Deviations from alternative 2a guidelines are included for active hurricane seasons

ALTERNATIVE 2B

This alternative represents a new approach to the regulation schedule for Lake Okeechobee. A desired lake stage curve, similar the Lake Okeechobee stage envelope PM, is the target:

- If the lake is below the stage curve, no regulatory releases;
- If the lake stage increases above the target stage, then successive regulatory release zones are encountered;
- The zones are roughly parallel to the target stage curve, and Zone A (maximum releases) is reached when the lake stage is roughly two feet above the target stage;
- Climate forecasting, as used in the current WSE regulation schedule, was also included (tributary hydrologic conditions are based on net rainfall and S-65E inflows to Lake Okeechobee)

ALTERNATIVE 2BS1

This alternative was developed from Alternative 2b. Alternative 2bS1 provides increased opportunity for base flow releases to the estuaries by lowering the bottom of Zone D1 (the lowest release zone) during the dry season.

ALTERNATIVE 3

This alternative is based on the Run 22AZE lake regulation schedule as previously evaluated under the WSE EIS (the previous lake regulation schedule study).

ALTERNATIVE 4

This alternative was developed from Alternative 1b, with the following modifications:

- Increase Zone B maximum Lake release to 6500/3500 and Zone C to 4500/2500;
- Lower regulation schedule during late hurricane season (change breakpoints for Zones A,B,C from 1 Oct to 1 Nov);
- Change decision tree for Zone C "base flow" to "up to Level 2";
- Change decision tree for Zone D for THC (tributary hydrologic conditions) "normal", SCO (seasonal climate outlook) "otherwise" to "up to Level 1";
- Change decision tree for Zone D for THC "normal or wet", MSCO (multi-season climate outlook) "otherwise" to "up to Level 1";
- Allow base flow releases to Caloosahatchee Estuary (450 cfs at S-79) to the following lake level: 1-1: 12.56; 9-1: 12.56; 10-1: 13.0; 12-31: 12.56 (target maintenance of lake stages above 12.56 navigation constraint stage and always above 2007LORS supply side management line);
- Releases south to WCAs discontinued below Zone D0, as in Alt1b;
- Deviations from alternative 4 decision guidelines are included for active hurricane seasons.

ALT1BS2-A, ALT2A-A and ALT4-A

Based on guidance from the Corps' District Engineer, the following three alternatives were modified to allow "up to maximum discharge capacity to tidewater" (Zone A) when Lake Okeechobee stage exceeds 17.25 feet:

- Alternative 1bS2 modification is denoted as Alt1bS2-A
- Alternative 2a modification is denoted as Alt2a-A
- Alternative 4 modification is denoted as Alt4-A

Prior to this modification, the proposed regulation schedules for alternatives 1bS2, 2a, and 4 allowed "up to maximum discharge capacity to tidewater" (Zone A) when Lake Okeechobee stage exceeds 17.50 feet. The maximum discharge line at 17.50 is the operational guideline during the period from September 30 through March 31. The above-indicated modified alternatives lower this maximum discharge line by 0.25 feet (down to 17.25 feet elevation) during this same period from September 30 through March 31. No additional changes to the alternatives were incorporated with these modifications to the maximum discharge line.

ALT2A-B and ALT3-B

Based on guidance from the Corps' District Engineer, the following two alternatives were modified to require "up to maximum discharge capacity to tidewater" (Zone A) when Lake Okeechobee stage exceeds 17.25 feet, and include a zone for base flow releases of 450 cfs to the Caloosahatchee Estuary:

- Alternative 2a modification is denoted as Alt2a-B. The previous Alt2a model update with 17.25 for maximum discharges (Alt2a-A summarized above) will be the starting point, with one additional change: base flow zone will be modified to allow zero base flow to St. Lucie Estuary (450 base flow to Caloosahatchee Estuary only) as included in all other alternatives; discharges to WCAs will not be modified from the development of Alternative 2a, with discharges discontinued below lake elevation of 13.50 feet. Alternative 2a previously included base flow deliveries of 50 cfs to the St. Lucie Estuary from Lake Okeechobee.

- Alternative 3 modification is denoted as Alt3-B. The modifications to the previous formulation of Alternative 3 include: Zones A and B modified to allow maximum releases at 17.25 feet (previously 18.50), and a base flow zone added (same as Alternative 2a and alternative 4)

Note: As under RUN22AZE (WSE EIS) and previous Alternative 3 modeling, discharges to WCAs are discontinued below Zone E (13.50-15.50 feet elevation).

2007LORS-FWO

A new alternative was recommended by the Corps' District Engineer. The new alternative is a modification to the current WSE regulation schedule, with changes to require "up to maximum discharge capacity to tidewater" (Zone A) when Lake Okeechobee stage exceeds 17.25 feet, and include a zone for base flow releases of 450 cfs to the Caloosahatchee Estuary. This run was created to represent the "future with operations modified" condition (fwo) that would be considered for implementation if one of the other LORS alternatives is not selected for implementation. Lors-fwo is a modification of the 2007LORS run; 2007LORS includes the current WSE regulation schedule, with maximum releases for Zone A defined for up to 18.50 feet elevation in Lake Okeechobee.

The modifications to the 2007LORS base, as required to create 2007LORS-fwo are summarized below:

- Zones A and B modified to allow maximum releases at 17.25 feet (previously 18.50)
- Base flow Zone added (same as Alternative 2a and Alternative 4; 12.56 is the navigation criteria for Lake Okeechobee)
- SSM line will be assumed lowered by 1.0 foot, as assumed for all other alternatives (see assumptions summary above)

ALT1BS2-M and ALT2A-M

Based on guidance from the Corps' District Engineer, Alternatives 1bS2-A and 2a-B were to be further modified. Alternative 1bS2-A was to be modified to eliminate all occurrences of Lake Okeechobee simulated stage above 17.25 feet, during the 36-year SFWMM period-of-record. Alternative 2a-B was to be modified to significantly reduce the frequency of extreme high discharge to the Caloosahatchee and St. Lucie estuaries, based on mean monthly flow volumes during the 36-year SFWMM period-of-record. The modified alternatives are denoted as Alternative 1bS2-m and Alternative 2a-m, respectively.

The modifications to Alternative 1bS2-A, as summarized below, were applied sequentially until the simulation results showed zero events above the stage of 17.25 feet for Lake Okeechobee:

- Regulation zones A, B, and C are lowered during the late hurricane season (September 30 stage breakpoints are changed to November 1, as under Alt4)
- Zone B breakpoints were lowered to be mid-way between the bottom of Zone A and the bottom of Zone C
- Lowered the bottom of Zone B by an additional 0.15 feet (in addition to #2) and lowered the bottom of Zone C by 0.10 feet, as the above modifications were unable to achieve zero exceedance of the 17.25 elevation

The modifications to Alternative 2a-B are summarized below:

- Increased releases in Zone Blue from 6,500/3,500 (Caloosahatchee/St. Lucie estuarine releases) to 7,500/5,000
- Changed Magenta regulatory releases to 800 cfs west / 400 cfs east measured at S-77/80 (Under Alternative 2a-B, the magenta zone was a zone allowing base flow to the Caloosahatchee estuary and regulatory releases south to the WCAs)
- Extended Magenta area to include below 13.5 ft to optimal line at 12.5 ft, consistent with the pre-defined operational guideline used to develop Alternative 2a
- Changed base flow line (bottom of orange zone) to match Alt1bS2 base flow zone

3. Final LORS Alternatives, General Overview

Following completion of the LORSS public meetings for the TSP and the receipt of public comments on the initial Draft SEIS, the decision was made to move forward with additional

modeling to evaluate the potential to improve the performance of the TSP. This decision was the result of Corps internal meetings on September 22, 2006.

The new round of modeling included revised data sets and updated assumptions, as summarized below. The previous model output was no longer used for LORSS PDT evaluations, and the old data was moved to the *Informational Runs* link on the LORSS modeling web page, to avoid confusion.

Updated 2007LORS Base Condition

- The seasonal and multi-seasonal forecast files that were used up to July 2006 (as used for the previous LORSS modeling) were mistakenly computed with La Niña threshold of -0.04. The updated base condition simulation was corrected by utilizing re-computed seasonal and multi-seasonal forecast input data files based on the correct threshold. The LONINO control volume used in the computation was based on S-80, which is specified in the WSE Water Control Plan. The La Niña threshold error dates back to the 2005 LECRWSP simulation, selected as the best available representation of WSE operations in February 2006.

- The District recommended use of the pump option at the S-8 structure to provide additional water supply deliveries to the Big Cypress Seminole Tribe reservation. Previous base condition and alternative modeling assumed gravity deliveries. Based on discussions with District staff, the pump operation is likely to be used to ensure delivery of water supply, specifically under drought conditions.

- The SFWMM subroutine that computes the capacity of the EAA canals under the neutral case had some legacy code that made it rely on parameter values for other "Low Lake Okeechobee Stage Management" (as opposed to using the SSM operations). The source code was modified to correct this minor error.

- L-8 regulatory releases from Lake Okeechobee and L-8 local basin runoff will be routed to tide (through S-155A) and will not be routed through STA-1E. Based on discussions with District technical staff, STA-1E is not designed to treat L-8 local basin runoff or Lake Okeechobee discharges (associated with higher nutrient load). Previous LORSS base condition and alternative modeling assumed treatment of L-8 local basin runoff and Lake Okeechobee discharges by STA-1E, resulting in additional volumes of water being passed through STA-1E, WCA-1, WCA-2, and into WCA-3A.

Updated Alt1bS2-A17.25 and Alt1bS2-m (the initial TSP selected in June 2006)

- The updated model assumptions described above for the 2007LORS base condition were applied to all of the alternatives in the final review.

- Updated SSM methodology (now termed Lake Okeechobee Water Shortage Management Plan [LOWSM]) was included in the updated modeling. Earlier alternative simulations

assumed a one foot lowering of the SSM line as a surrogate for this LOWSM plan that was under development by the District. The operational details of the LOWSM plan were provided to the LORSS PDT team by the District on October 10, 2006. The LOWSM methodology is not included in the SFWMM source code used for the base condition, 2007LORS.

- Modified Low band breakpoints to assume Level 1 pulse releases within the bottom 1/3 of the band, Level 2 pulse releases within the middle 1/3 of the band, and Level 3 pulse releases within the upper 1/3 of the band. The previous modeling of Alternatives 1b, 1bS2, 1bS2-a17.25, 1bS2-m, and 4 included model inputs that resulted in a narrow band for Level 3 pulse releases within the Low band; the previous modeling did not modify the Low band breakpoints when the bottom of the intermediate band was lowered from alternative 1a to alternative 1b (and all derivatives from Alternative 1b). The operational decision tree for the low band does not specify the level of pulse release within the band (up to Level 3 pulse is allowed), and both modeling approaches do fall within the operational range of the low band.

Based on consideration of public and agency comments, three additional alternatives were developed in an effort to demonstrate potential improvements to the initial TSP plan. In an effort to allow the storage of additional water within Lake Okeechobee (compared to the initial TSP Alt1bS2-m), while simultaneously recognizing the need to provide for public health and safety under high lake levels, the starting point for these additional alternatives was the updated version of Alt1bS2-a17.25.

Alternative T1

Alternative T1 (TSP modification 1) was proposed by the Corps Water Management Section. The following changes were made to Alternative 1bS2-A17.25:

- Changed the late season break points from September 30 to November 1 for the top of the High, Intermediate, and Low bands to address the potential of late season hurricanes.

- Changed the Level 3 pulse release measured at S-77 from an average daily flow of 3,000 cfs to 2800 cfs.

- Included a base flow of 350 cfs to the St Lucie, measured at S-80, in low and intermediate bands.

- Changed the base flow on the Caloosahatchee from up to 450 cfs at S-79, to up to 650 cfs measured at S-77, in the low and intermediate bands.

- No changes to base flow of 450 cfs measured at S-79 in the base flow band.

- Raised the bottom of the base flow band by 0.25 feet.

- Change the High and Intermediate band flow of up to 2,800 cfs measured at S-80 back to the WSE level of up to 3,500 cfs.

Alternative T2

Alternative T2 (TSP modification 2) was proposed by the District. The following changes were made to Alternative 1bS2-A17.25:

- Zone D0 raised to 12.6 ft (Zone D0 should be higher than navigation minimum of 12.56').

- All Caloosahatchee pulse releases are measured at S-79 instead of S-77 (in all lake bands when pulse releases are called for, to reduce high flow exceedences caused by lake release plus runoff).

- Bottom of Zone D1 lowered by 0.5 ft (to encourage more pulse releases which help reduce steady high discharges).

- Added a small base flow of 200 cfs (*i.e.,* low volume regulatory discharge) at S-80 (whenever base flow releases are called for in decision tree).

Alternative T3

Alternative T3 (TSP modification 3) was developed through the collaborative efforts of the Corps and District, following LORSS PDT review of the updated alternatives and the new T1 and T2 alternatives. Alternative T3 was developed from Alternative T2, with the following changes:

- Changed the late season break points from September 30 to November 1 for the top of the High, Intermediate, and Low bands to address the potential of late season hurricanes (consistent with alternative T1).

- Inclusion of an Oct. 1 breakpoint at 13.0 ft for the bottom of the base flow Zone D0 (consistent with original LORS Alternatives 2a and 4 to provide some protection to low lake levels at the end of the wet season).

- Increased Caloosahatchee Level 1 pulse from average daily rate of 1,600 cfs to 2,000 cfs (allows for increased releases below 2,800 cfs to reduce higher lake levels and the associated higher releases).

- Increased Caloosahatchee Level 2 pulse from average daily rate of 2,300 cfs to 2,500 cfs (allows for increased releases below 2,800 cfs to reduce higher lake levels and the associated higher releases).

- Caloosahatchee Level 3 pulse remain unchanged, at average daily rate of 3,000 cfs.

- Reduce maximum Caloosahatchee discharges from 4,500 cfs to 4,000 cfs when the Lake Okeechobee stage is within the intermediate (normal to wet) or low (very wet) bands.

VIII. EVALUATION OF THE ALTERNATIVES

Project alternatives were analyzed in a step-wise manner. Each alternative was evaluated against the others, and against the 2007LORS No Action alternative in order to identify which ones best approached the multiple goals of the project. The outcome of each step in the analysis resulted in the modification of several of the alternatives to improve their performance for continued evaluation.

Alternatives were evaluated by comparing their respective performance measure outputs from the SFWMM against each other and against the base alternative (2007LORS). Each PDT member agency conducted their own evaluations, and these agency evaluations were shared with the entire PDT and discussed during weekly meetings. The Service focused its evaluations on the ecological performance measures, primarily those related to lake ecology and the estuaries, but also paid special attention to evaluations of the Everglades indicator regions that were led by the District.

After the Corps reviewed the public comments regarding the TSP outlined in the initial Draft SEIS, the decision was made to reformulate the alternatives, and further develop the TSP so as to improve its performance in several areas, particularly its effects on the Caloosahatchee River and estuary. At the same time, the Corps modelers took the opportunity to address several deficiencies in the existing model by modifying assumptions and updating some model parameters to increase its accuracy and reliability. Although most of these model changes were minor and unrelated, the net effect of the changes was enough to change the performance output for all modeled alternatives. Consequently, the results of the modeling that was conducted during the final alternative evaluation cannot be compared to the earlier modeling results.

The tables that have been included with this report document the environmental performance measure model output for only the final set of alternatives. The same performance measures were used by the Service to evaluate all alternatives throughout the history of this project, but only those modeling results for the last tier of alternatives are included in the evaluation tables, due to the incompatibility of comparing them with the older model results. Tables of the old series of alternative evaluations are included in the Appendix to illustrate the respective performances of all the project alternatives from the beginning of plan formulation.

Caloosahatchee Estuary

Performance measures for the Caloosahatchee estuary are tied to freshwater flow rates measured at S-79, including lake releases. Flow rate is used as a surrogate measure for estimating the salinity within the estuary. Please refer to Table 1 for a side-by-side comparison of the final tier of alternatives and their respective performance measure output. The model output for the initial alternative evaluations can be found in Table A-1 of the Appendix.

Initial Alternatives

From the beginning of the project evaluation, the Service supported variations of the *Alt1* line of alternatives. During the first tier of evaluations, Alt1 provided the best performance for the Caloosahatchee estuary, particularly in reducing the number of high flow events (>2,800 cfs). When this alternative was modified and split into derivative alternatives, we supported, in sequence, Alt1a, Alt1aS2, and finally Alt1bS2-A, all for the reasons of reducing the number and duration of high flows to the estuaries. Due to the inclusion of base flow requirements, these alternatives were also very successful at reducing the number of low flow events to the estuaries. When Alt1bS2-A was modified to Alt1bS2-m (which was picked as the original TSP), its performance for high flows was degraded considerably.

The series of *Alt2* alternatives never performed well for the Caloosahatchee. This line of alternatives was designed from the beginning to reduce high stages within Lake Okeechobee to the maximum extent possible, which resulted in the consequent negative impacts on the downstream estuaries. In all derivations of this series of alternatives, the high flows to the Caloosahatchee were increased in both number and duration of the events. The Service consistently did not support any version of the Alternative 2 series. However, during the last revision of the final two alternatives prior to the release of the initial draft of the SEIS in August 2006, Alt2a was changed to Alt2a-m and its performance for reducing high flows was drastically improved, and substantially exceeded the performance of Alt1bS2-m (which had been chosen as the initial TSP).

Alternative 3 was initially included in the project evaluation as a holdover from the last time the regulation schedule was revised (it was originally known as Run22 AZE). It was not expected to perform well during the current schedule revision, because the water management system and its operations have changed considerably since this alternative was first developed. Indeed, the initial incarnation of Alt3 had mixed performance results for the Caloosahatchee. While it reduced the total number of high flow events to the estuary, those that remained tended to have much larger flows and for substantially longer durations. Additionally, the number of times that the minimum low flow targets were not reached during the dry season increased slightly over 2007LORS, due to the lack of base flow releases to the estuaries in this alternative. However, when this alternative was modified to include base flow and other minor improvements (then called Alt3-B), its performance in the Caloosahatchee was improved to a significant degree, and it ended up being one of the best, if not *the* best, alternative for the Caloosahatchee estuary. Unfortunately, its poor performance in other parts of the system precluded it from being selected as the TSP.

The two variations of Alt4 had mixed results for the Caloosahatchee. While they performed well in most categories, such as reducing the total number of high flows (>2,800 cfs), they also increased the number and duration of the extreme high flow events (>4,500 cfs). Alt4-B was not selected as the initial TSP due to poor performance in the lake.

Final Alternatives

Alternatives Alt1bS2-A and Alt1bS2-m (the initial TSP) were both re-modeled with the improvements to the model. Additionally, Alt1bS2-A was also revised sequentially to develop

Alternatives T1, T2 and T3 (the new TSP). Generally speaking, the revised Alt1bS2-A and Alt1bS2-m performed better than their initial versions, with the important exception of the long duration extreme high flows to the Caloosahatchee estuary. Alternatives T1 through T3 all offered improvement over the initial TSP, with T2 and T3 performing the best. The differences between T2 and T3 were minor, however, T3 has fewer long duration high flows (>45,00 cfs for >5 weeks) than T2.

Compared to the 2007LORS base run, Alt-T3 would reduce the total number of high flow events (>2,800 cfs) from 74 to 64 over the period of record (a 14 percent decrease from the base run). The number of extreme high flow events (>4,500 cfs) would remain unchanged at 29, but the duration of these events would be increased, with the number of times the moving weekly average flow exceeding 4,500 cfs for longer than five weeks increasing from 28 to 65. The end result of this analysis is that the proposed TSP would likely have a net positive effect on the upper estuary, but with the cost of potentially worsening conditions in the lower estuary and San Carlos Bay.

St. Lucie Estuary

As with the Caloosahatchee, freshwater flow from Lake Okeechobee was used to measure the performance of the alternatives with respect to their effects on the salinity within the St. Lucie estuary. Please refer to Table 2 for a listing of each of the final tier of alternatives with its respective performance measure output. The model output for the initial alternative evaluations can be found in Table A-2 of the Appendix.

Initial Alternatives

The performance of the initial alternatives for the St. Lucie River and estuary is very similar to their performance in the Caloosahatchee, although with far less dramatic differences. As with the Caloosahatchee, the variations of Alt1 tended to be some of the better performing alternatives, and the variations of Alt2 tended to perform worse. Again, Alt3-B was an exceptional performer for all performance measures except for low flow events, but as already mentioned, this alternative was eliminated because of poor performance in the lake. Unexpectedly, Alt4 and Alt4-B performed consistently well in this estuary, but again, poor lake performance precluded them from selection.

Final Alternatives

The only alternative in the final tier that did exceptionally well in the St. Lucie was Alt-T1. However, since T1 was considered unacceptable from the perspective of the Caloosahatchee, Alt-T2 was further refined to result in Alt-T3, which greatly improves the performance over T2 for the St. Lucie. Alt-T3 improves low flow considerably, and very slightly reduces the number of high flow events (>2,000 cfs) from the base condition, though not to the extent that T1 did. For some reason, T3 increases the frequency of average bi-weekly flow events (>2,000 cfs) from the local drainage basin, though the number of these events coming from lake discharges would be reduced relative the No Action alternative.

Lake Okeechobee

As can be expected, those alternatives that performed best for the estuaries did not perform as well for Lake Okeechobee. Please refer to Table 3 for a side-by-side comparison of the final tier of alternatives and their respective performance measure output. (Table A-3 in the Appendix shows this same information for the initial set of alternatives.) The intent of environmentalists over the past 15 years or more has been to lower the average annual lake stage. In reviewing our files, we found that the general consensus was that the lake elevation should be an average of two feet lower than the current average annual elevation; however, the results of the modeling study for this project show that an average 2-foot drop may, in fact, be excessive. The initial TSP (Alt1bS2-m) lowered the average lake stage about 1.0 to 1.5 ft lower than 2007LORS, depending on the time of year (this is approximately 2.0 to 2.5 ft lower than actual levels). While this drop in elevation is desirable from a flood control perspective, it may end up causing harm to the lake's littoral zone due to drying out too frequently, and for longer periods of time, in drought years.

The problem inherent with moderating the extreme highs and lows of the average lake elevation is that it is difficult to devise operational strategies that simply shave off the high and low peaks from the annual stage hydrograph. As the modeling of the numerous alternatives for this project demonstrates, the annual hydrograph generally maintains a consistent shape between alternatives, with the entire hydrograph rising or dropping dependent upon the particulars of a given alternative. Consequently, those alternatives that are best at reducing the high peaks in the average lake elevation also tend to increase the severity of the low troughs, causing the lake elevation to fall lower for longer periods of time.

Initial Alternatives

Those alternatives derived from the original Alt2 consistently lowered the lake to the greatest extent (sometimes over 1.5 ft lower than 2007LORS, or 2.5 ft lower than current levels). For certain groups of performance measures, for example those associated with flood control, the Alt2 variants produced the best performance, but at a cost to the ecological performance measures. The periods of time when the lake's littoral zone dried out tend to be more extreme and last longer with the Alt2 series of alternatives.

The Alt1 derivatives also lowered the lake stage, showing a marked improvement over the baseline alternative (2007LORS), but they did not lower the lake to the same extent as the Alt2 series of alternatives. During the early evaluations of the project alternatives, the Alt1b variations consistently scored highest in overall performance (including the estuaries and other downstream systems), and demonstrated the best overall balance of project objectives. But when the goal of the project changed to maximize flood control at the expense of all other competing project objectives, only the Alt2-series of alternatives remained viable.

The last alternative modifications prior to the release of the initial Draft SEIS (which changed Alt1bS2-A to Alt1bS2-m, and Alt2a-B to Alt2a-m), reversed the performance of the two originating alternatives. Alt2a-B, which was originally best for the lake and worst for the estuaries reversed itself, and became better for the estuaries. Similarly, Alt1bS2-A was originally better for the estuaries than Alt2a but not as good for the lake (it exceeded the 17.25 ft

high lake stage constraint for 12 days out of the 36 year period of record), and was changed to improve its performance in the lake (by removing any days in the simulation exceeding the 17.25 ft constraint), but became damaging to the Caloosahatchee estuary. This was the alternative that was chosen as the initial TSP, and consequently generated a large amount of negative public feedback.

Final Alternatives
The final tier of alternatives was based on Alt1bS2-A, and therefore did not negatively affect the Caloosahatchee to the same extent as the initial TSP (Alt1bS2-m). Their effects on the lake, however, were less straightforward. It appears that the new TSP, Alt-T3, lowers the lake more often than the initial TSP, but for shorter periods of time. For example, the new TSP, Alt-T3, drops the lake stage below 13.5 ft 31 times over the period of record, with an average duration of 236 days for each event, but the initial TSP, Alt1bS2-m, would have dropped the lake below this stage 27 times with an average duration of 255 days per event.

Greater Everglades
The Service initially evaluated the project alternatives relative to several downstream performance measures, including the effects to snail kites and the Cape Sable seaside sparrow within the WCAs and Everglades National Park. Our review of the model output showed that although there were some differences in the performance of the alternatives, these differences showed no discernable pattern, and were very minor. This is likely because the operational decisions in the SFWMM operate the WCAs on the line of their respective regulation schedules. We therefore chose to concentrate our review on the effects of the project on the estuaries and lake ecology.

The District conducted their own review of the project effects within the Everglades, and we referred to their analyses during the PDT discussions of alternative performance, paying particular attention to the performance measure for snail kite habitat. Their evaluation reinforced our opinion that project effects in the downstream WCAs were insignificant. We were encouraged to note that even given the minor differences between the alternatives, all of them performed slightly better than the baseline for snail kite habitat, though it is debatable as to the significance of their improved performance.

IX. POTENTIAL ADVERSE AND BENEFICIAL EFFECTS OF THE TENTATIVELY SELECTED PLAN

A. Effects on the Caloosahatchee Estuary

The effects that the final TSP (Alt-T3) has on the Caloosahatchee River and estuary are complex and in some ways contradictory. There are several data output parameters from the SFWMM that help to shed light on the manner in which this alternative affects freshwater flows to this system. First, Alt-T3 would decrease the amount of water (on an annual average) sent to the river and estuary due to regulatory releases by approximately 3,730 af (about 1 percent of the 2007LORS flow). The amount of water sent to the Caloosahatchee in the form of base flow releases sent during the dry season and periods of drought will increase by 40,370 af, for a net

total increase in annual average flows of 36,640 af. This represents approximately a 10 percent increase in flows from the 2007LORS to the TSP. Because all of the additional increased flow would be intended to reduce the number of low flow events, this would be considered a beneficial effect to the estuary, except perhaps for water quality issues.

Another measure of high flow to the estuary is the moving average weekly flow >4,500 cfs measured at S-79. The TSP reduces the number of these events compared to the 2007LORS base condition by 17 weeks (132 weeks in 2007LORS to 115 weeks in Alt-T3, a 13 percent reduction). However, in examining the distribution of these moving average weekly flows >4,500 cfs, we noted that the flows that remain are more tightly clustered in the TSP, so that each event with a flow >4,500 cfs lasts longer than the corresponding events in the 2007LORS base run. The number of long duration, extreme high flow weeks (> 4,500 cfs for more than 5 weeks) would more than double from 28 to 65 over the 36 year period of record. Because the long duration flows greater than 4,500 cfs are the most damaging to the lower estuary from Shell Point to San Carlos Bay and the J.N. "Ding" Darling NWR, the Service is very concerned about the increase in the duration of these flows. The TSP is essentially redistributing the flows to the Caloosahatchee in a manner that decreases the number of times that damaging flows reach the estuary, but increasing the duration and severity of those flow events that remain.

Overall, the total amount of water released during regulatory discharges would be reduced, as would the number of times these large discharges would need to be made, but when these high flow events increase substantially in duration, impacts to the lower estuary can be severe. Oysters and seagrass beds are important estuarine resources in this area that would be negatively impacted by these long duration extreme high flows. They are sessile species that cannot move to areas of preferred salinity ranges although they can tolerate low salinity levels for short durations. These species become more susceptible to disease, predation, and even death as the duration of extreme high flow events increase. The TSP therefore has a greater potential than the base condition to reduce the density and cover of seagrass beds in the lower estuary and/or contribute to shifts in their community composition. Additionally, the TSP has a greater potential than the base condition to reduce the abundance and productivity of oysters in the lower estuary and potentially flush oyster spat downstream to areas less suitable for establishment and long-term survival.

A positive benefit of the TSP is that it is very effective at reducing the number of low flow events. As previously discussed, a minimum amount of freshwater flow from the lake is necessary during the dry season to compensate for the lack of fresh water flowing into the estuary from the local drainage basin. The total number of low flow events over the 36-year period of record would be reduced by 34 percent under the TSP. The TSP would, therefore, benefit the estuary by providing water to the estuary when there is little to no basin flow due to limited rainfall and increased water supply demands, with the exception of potential increase in nutrient loading. The decrease of low flow events would likely reduce the frequency of MFL violations in the Caloosahatchee, and help to maintain the long-term viability of the *Vallisneria* beds in the upper estuary.

B. Effects on the St. Lucie Estuary

The effects of the final TSP (Alt-T3) on the St. Lucie estuary are less dramatic than on the Caloosahatchee estuary. The total number of monthly high flow events (>2,000 cfs) is reduced only slightly, from 74 to 73 over the period of record. Extreme high flow events (>3,000 cfs) remain unchanged from the base run. The number of times that large regulatory releases are made from the lake with moving bi-weekly average flows >2,000 cfs would be reduced from 52 to 49, but this drop would be offset by an increase in the bi-weekly high flow events from the local drainage basin, from 72 to 79 events.

The total amount of water sent to the St. Lucie on an average annual basis would increase by 22,820 af, most of which would be in the form of base flow releases during the dry season. Although the current opinion of estuarine experts is that the St. Lucie estuary does not require a minimum amount of base flow from Lake Okeechobee in order to maintain proper estuarine salinity levels during the dry season, it would still be beneficial to reduce these low flow events to the extent possible. The TSP reduces the total number of low flow events substantially, from 127 to 103 events over the period of record compared to the 2007LORS (a drop of almost 20 percent).

C. Effects on the Lake Okeechobee Littoral Zone

Any alternative that does not substantially "flatten" the annual hydrograph can be only marginally successful at restoring the lake's littoral zone close to the more favorable vegetation patterns in the Pesnell and Brown (1977) littoral zone survey. However, this cannot be achieved with the current infrastructure surrounding the lake; much more dynamic storage will need to be connected to the lake. Lowering the annual average lake elevation typically results in lowering the probability of ecological stress due to high lake stages, yet increasing the probability of stress because of low lake stages. Of particular concern is the suitability of the littoral habitat for the apple snail, which is a nearly exclusive food source for the endangered snail kite.

The apple snail is not a very mobile creature. Unlike some other aquatic animal species, apple snails will not move extensively to follow the optimal water conditions that will vary with season and year (Darby et al. 2002). When a portion of the littoral zone inhabited by apple snails dries out because of lowering lake stage, the snails will imbed in the surface layer of detritus, and await the return of the water. After a period of time, the snails will die if the area remains dry. Therefore, when discussing the drying of the littoral zone, it is important to keep in mind not only how dry (*i.e.,* how low the water gets), but even more importantly, for how long.

Very high water levels are also destructive to snail habitat. Once the water depth in a particular area exceeds approximately 40 cm, the area is considered to be too deep to allow snails to breed. Higher lake stages also allow wind storms to tear out emergent vegetation, particularly along the outer edge of the littoral zone. Because the snails must breath air, they need stems to climb to survive; they also need portions of the stems to remain above water level for their eggs to hatch. When the extremely high lake stages are regularly interspersed with extremely low lake stages, apple snails are never given an opportunity to recover their numbers. Because of this, those

alternatives that show large intra-annual variation in water elevations, in particular during the spring snail breeding season, are poorly suited to providing and maintaining good apple snail habitat. The TSP is neither better nor worse than the other alternatives in providing a more even water elevation during the spring, however it does increase the extent of the littoral zone that dries out during each low water event, and also increases the amount of time that the littoral zone remains dry, thereby increasing the mortality of apple snails. However, it also decreases the maximum water depth and number of times that the littoral zone becomes too deep to support breeding snails.

We predict that the performance of the TSP would be better than the 2007LORS run for wading birds. Because fish, amphibians and large crustaceans tend to be the most common food source for wading birds, shallow water and gradually receding water levels are very important for concentrating their food supply. Unlike the apple snail, these prey items can move with lowering water levels to varying degrees, so actual water elevation is not as important to wading birds as is the rate of elevation change during the spring. This is called the spring recession period, and the TSP performs slightly better than the 2007LORS alternative in providing gradual recessions during the spring months. In addition to the greater ability of fish to persist through periods of lower water levels, they also are more rapid in repopulating the littoral zone once it has re-flooded. This is the basis for our finding that lower water levels are generally beneficial for wading birds, including the endangered wood stork, while at the same time would, on balance, have some adverse effects on the endangered snail kite.

D. Effects to the A.R.M. Loxahatchee NWR

The existing performance measures for this project are too coarse to adequately evaluate potential effects to the Refuge. The primary concern is that the annual average water elevation within Lake Okeechobee will drop to such a degree as to prohibit the pre-emptive replacement water releases to the Refuge. These releases can only be made if the water elevation within the lake is no more than 1.0 ft lower than the water elevation within the Refuge. Although it is difficult to compare the water elevations from a model run to elevations from the historical record, it appears as though the TSP will lower the average annual water elevation in Lake Okeechobee by about 1 to 2 ft, depending on the time of year. When comparing the stage hydrographs for Lake Okeechobee and the Refuge, it appears that over the 36-year period of record, there would have been only a single instance of replacement water not being able to be sent from the lake to the Refuge in both the TSP and the 2007LORS run, so there would apparently be no effect on the Refuge from the TSP.

Review of the stage duration curves for indicator regions within the Refuge shows that the TSP would have very little effect on Refuge water elevations, although there is a slight increase in stage duration at the dry end of the duration curve, which would be a benefit to the ecosystems within the Refuge. More detailed and in-depth analyses of this issue will be needed for the next revision to the regulation schedule to be implemented in 2010.

The Service is uncertain why the current modeling does not show obvious impacts to the Refuge, when the empirical evidence from past droughts would suggest that the impacts on the Refuge

may be more significant than the modeling predicts. There are a number of possible explanations for this apparent discrepancy. One explanation is that, in fact, this change in regulation schedule would not adversely impact the Refuge. Another might be that the SFWMM lacks adequate spatial resolution to detect impacts on the Refuge. A third possibility is that the model insensitivity is a result of the operational decisions within the SFWMM to operate the Refuge "on the line" of the WCA-1 regulation schedule. A fourth possibility is that the consumptive use of water from the Refuge is not adequately modeled in the SFWMM. Finally, the SFWMM does not account for the increased risk to the Refuge due to more frequent and longer deviations from the Refuge's water regulation schedule to meet water supply demands.

E. Lake Okeechobee Minimum Flows and Levels (MFL)

The MFL documentation for Lake Okeechobee states that the harmful lake stage of <11 ft for >80 days should not occur more than once every six years. The final TSP (Alt-T3) slightly increases the number of times the lake drops below 11 ft for more than 80 days compared to the 2007LORS base condition (an increase from 5 to 6 times). The lake stage hydrograph for the period of record indicates that the low lake stages from the TSP tend to be grouped into three periods when two low water events occur within six years of each other, resulting in three violations of the MFL regulations. In contrast, the 2007LORS base run shows two violations of the MFL.

Because the TSP would increase the frequency and duration of extreme low water events to the degree that there may be additional violations of the MFL, this may necessitate the implementation of a recovery strategy for mitigating impacts on the lake. In recent public forums, the Service has heard discussion of possibly reseeding apple snails in the littoral zone to mitigate these adverse effects. While the Service supports the testing of this method of species conservation through a pilot study, it is unclear if this will prove to be a viable strategy to compensate for the adverse effects the TSP may have on snail kites. A pilot study could determine if reseeding snails into the littoral zone after drought has a localized effect in speeding up recovery of apple snail populations. However, to be part of an effective recovery strategy for the snail kite, it would have to be practical on a larger scale. We also must point out that a large standing stock of apple snails would have to be maintained continuously at the ready in case a drought occurs, but unlike several recreationally important fish, we are unaware that this stock is already commercially available.

F. Operational Guidance

Appendix A of the Draft SEIS describes overall operational guidance for the Lake Okeechobee regulation schedule. This guidance emphasizes the need for Additional Operational Flexibility (previously known as Non-Typical Operations) for water managers to be able to respond to unanticipated events outside of the normal predictive capability of the TSP modeling. The result of such a wide degree of operational flexibility is that the hydrologic models used in plan formulation may no longer reflect the operations of the prescribed plan. The Corps states in the Draft SEIS that this additional operational flexibility would be rarely invoked, but the

circumstances they describe that would warrant implementation of the increased operational flexibility are very broad.

The operational guidance also proposes the concept of "make-up" discharges from the lake. This basically addresses the instances when water managers want to release water from the lake to downstream systems, but are precluded from doing so due to restrictions in the regulation schedule that limit the amount of water that can be sent to specific areas at specific times. This would essentially create a "backlog" of releases that would be carried out in large quantities at a later date, which may have unanticipated negative effects on the downstream systems to which this water is released.

An integral component of the proposed operational guidance is the use of District (and other state-owned) lands as temporary water storage facilities for times when the lake needs to be lowered, but releasing water to the estuaries would be undesirable. This is a concept that has only recently been added to the operational guidance, and has not been fully evaluated for its environmental consequences to the receiving lands. Nor have the practical aspects of implementing this strategy been fully investigated, and more work needs to be done to determine the effectiveness and practicality of this proposed measure.

G. Summary of Consultation under the Endangered Species Act

On June 30, 2006, the Service received a letter from the Corps requesting initiation of formal consultation under the provisions of section 7 of the ESA. The consultation concerns the possible effects of the proposed revision to the WSE regulation schedule for Lake Okeechobee on the following federally listed species:

COMMON NAME	SCIENTIFIC NAME	STATUS
Snail kite	*Rostrhamus sociabilis plumbeus*	E (CH)
Wood stork	*Mycteria americana*	E
West Indian manatee	*Trichechus manatus*	E (CH)
Bald eagle	*Haliaeetus leucocephalus*	T
Cape Sable seaside sparrow	*Ammodramus (=Ammospiza) maritimus mirabilis*	E (CH)
Eastern indigo snake	*Drymarchon corais couperi*	T
Okeechobee gourd	*Cucurbita okeechobeensis* ssp. *okeechobeensis*	E

E=Endangered; T=Threatened; CH=Critical Habitat has been designated

The Corps provided a Biological Assessment to the Service that stated the proposed TSP was not likely to adversely affect any of the above-mentioned species. The Service has reviewed the analysis of the hydrologic changes predicted for the regulation schedule and based on our knowledge of the project and our preliminary analysis of the modeling results, we concurred with the Corps' determination that the proposed project will have no effect on the bald eagle, eastern indigo snake, West Indian manatee, and the Cape Sable seaside sparrow, or result in destruction or adverse modification of designated critical habitat for the manatee or the Cape Sable seaside sparrow. We also concurred that the project may affect, but is not likely to

adversely affect the wood stork, and Okeechobee gourd. We determined that the project may affect the Everglade snail kite, and we will include this species in the biological opinion produced from this consultation. Our early analysis indicates that the Corps' assertion of net positive effects for the wood stork and the gourd are probably correct. However, we cannot agree that the project will have a beneficial effect on the Everglade snail kite. Specifically, the Service is concerned about the effects of the TSP on the apple snail population within the lake's littoral zone, and the resulting effects on the kite. Our complete analysis of the effects of this project on the snail kite and its critical habitat will be included in our forthcoming biological opinion.

X. RECOMMENDATIONS/CONSERVATION MEASURES

Lake Okeechobee has been called the heart of the central and south Florida water management system. As such, the schedule that regulates when, where, and how much water is released from the lake to downstream systems is a critical component in maintaining a proper water balance throughout south Florida. The Service is providing recommendations on this project in order to make the project more environmentally compatible and to further enhance the diversity and abundance of fish and wildlife resources in the project area. In view of the broad reach in time and geographic area of the potential effects of this project, our recommendations are mid- to long-term, including the next phase in the development of the regulation schedule that will incorporate the Band 1 set of CERP components.

1. The federally endangered Everglade snail kite has suffered a decline throughout south Florida over the past decade, and its nesting effort and success in Lake Okeechobee has been low for about 15 years. This is because, in part, to the drop in numbers of apple snails within the lake's littoral zone. Our understanding of the current status, distribution and population trends of the apple snail in the lake is incomplete. To provide this critical information, we strongly recommend that an annual monitoring program be implemented, in selected sample locations throughout the littoral zone of the lake.

2. The existing CERP performance measures for evaluating project effects on snail kites are difficult to apply to Lake Okeechobee. The Service is committed to assist in developing reliable and sufficiently sensitive performance measures to specifically analyze the effects on snail kites feeding and nesting and in the lake.

3. We believe that the Regional Simulation Model (RSM) will be more effective in analyzing effects of the regulation schedule and should be used in place of the SFWMM during the next revision of the regulation schedule. The RSM will provide better resolution of key areas of ecological concern (including A.R.M. Loxahatchee NWR; see below). Although some initial screening of alternatives could be performed with the SFWMM, we believe that the final plan should be selected from the final suite of alternatives with the more powerful RSM. This will require substantial effort to develop, test, and calibrate the RSM model, which is currently not in routine use.

4. The Service finds that current indicator regions and performance measures do not adequately assess the effect of the Lake Okeechobee regulation schedule on A.R.M. Loxahatchee NWR (WCA-1). The regulation schedule for Lake Okeechobee has a direct influence on the ability to provide replacement flows to the Refuge in response to urban water supply demands. We recommend that modelers review how accurately simulations capture the effects of water supply withdrawals from WCA-1 during periods of drought and the degree of impact such withdrawals will have on the need to seek deviations from the 14 ft floor of the regulation schedule for WCA-1. The Service believes that the necessary revisions to indicator regions in the Refuge and improved simulation of water supply demands can be achieved in the transition from the SFWMM to the RSM, and these need to be completed prior to selection of alternatives in the next phase of planning for the regulation of Lake Okeechobee.

5. To reduce the dependency of the Lake Worth Drainage District (LWDD) on water drawn from A.R.M. Loxahatchee NWR to meet dry season demands, we recommend that the LWDD's recommendations be implemented to route water from the C-51 Canal around the Refuge to the E-1 Canal. We believe the relatively modest structural modifications needed to achieve this goal can be implemented well before construction is completed on the CERP Band 1 projects. Incorporating this capability into the simulations in the next phase of planning for regulation of Lake Okeechobee would be advantageous in minimizing adverse effects of low water on the Refuge.

6. Potential impacts to the lower Caloosahatchee estuary and the J.N. "Ding" Darling NWR from high freshwater flows could be better assessed with more intensive monitoring programs. We recommend that salinity, water quality (*e.g.,* nutrient levels and other parameters) and aquatic vegetation monitoring be established and/or expanded to locations not currently monitored.

7. The Service recommends that the next schedule revision prioritize reducing both the number and duration of flows greater than 4,500 cfs at S-79 resulting from regulatory releases.

8. Water quality concerns in the Caloosahatchee and St. Lucie estuaries were not adequately evaluated in the current regulation schedule study. The CERP program has several water quality performance measures designed specifically to analyze nutrient issues in the northern estuaries, and we recommend that these performance measures should be used for the next schedule revision in 2010.

9. Base flow (or the lack thereof) to the Caloosahatchee estuary is a component of the MFL for this estuary. The Caloosahatchee is burdened with an unfair portion of the "shared adversity" when discharges intended to prevent violations of the MFL are terminated at a higher lake stage than the initial level of cutbacks to water consumers in the EAA in accordance with the LOWSMP. The Service recommends that future revisions to the schedule include delivery of a base flow to the Caloosahatchee that will not be curtailed until the initial phases of water supply cutbacks are in effect.

10. The Operational Guidelines for the LORS were revised at the very end of the project evaluation, with very little time for input from the PDT. During the next regulation schedule revision, discussions regarding the guideline revisions should occur concurrently with the regulation schedule revision process, so that PDT member concerns can be addressed adequately and completely.

11. Appendix A of the Draft SEIS describes overall operational guidance for the Lake Okeechobee regulation schedule. While a certain level of operational flexibility is desirable, we find that the proposed operational guidance is too vague and provides an excessive level of flexibility leaving too much uncertainty for stakeholders. The next phase of this study in the years 2007 to 2010 should attempt to ensure that the hydrologic models used in plan formulation follow as closely as possible the proposed operations of the prescribed plan. Aside from building trust among the stakeholders, we believe this disciplined approach has some very pragmatic advantages. First, closely following the operations described in the model should allow feedback into adaptive management of the lake which will be increasingly important as features of the CERP come on line. Conversely, too much operational flexibility will not allow confidence in the ability of the hydrological models to reflect what has happened or to predict the effects of proposed changes in and around the lake. Second, other critical components of the C&SF system intimately linked to the central role of Lake Okeechobee in water management for south Florida must have consistent modeling assumptions about operation of the lake to make them work effectively together. Such consistency would be invaluable for the next revision of the Systems Operating Manual, which is a separate planning effort for managing water in south Florida.

    The Service recognizes that the Corps and the District have distinct authorities; within their partnership, the Corps takes the lead on decisions related to operation of the C&SF system for flood control, and the District has the primary authority with respect to water allocations. However, these two aspects are inextricably linked in terms of the overall water budget for the lake. Regardless of any legal decisions about what may be termed a Federal action or a State action, accurate modeling of the water budget requires both agencies to reach agreement throughout the planning process on management decisions across the full range of water conditions. In the current plan formulation effort, the Corps and the South Florida Water Management District had difficulty in coordinating these decisions, particularly with respect to acceptable risks to the integrity of Herbert Hoover Dike, the potential use of District-owned lands to store water, the use of managed recessions, and changes to water shortage planning. We believe that these decisions must be reached in a timely fashion so they can be reflected as accurately as possible in the model simulations in the final comparison of alternatives before selection of a TSP. This will, as mentioned above, contribute to the confidence of stakeholders, and will ensure that the analysis leading to the consultation findings under the ESA are based on the best available technical information.

12. The operational guidance proposes the concept of "make-up" discharges from the lake. We do not recommend inclusion of make-up discharges in the plan because they create an additional layer of uncertainty to stakeholders with, in our opinion, relatively little overall benefit. If the Corps prefers that make-up discharges be maintained as part of the plan, we suggest that the Final SEIS describe the temporal and volumetric limits for these additional releases. We would be concerned about creating a large "debt" or "backlog" of releases that would be carried out in large quantities at a later date. In addition to setting such limits, the Final SEIS should describe a notification and accounting methodology so that concerned agencies and the public can track the accumulated discharge "debt," the rate and timeframe for the make-up releases, and notification of when these periods start and finish.

13. The operational guidance states that periods of Additional Operational Flexibility should be rare events. We also believe that these events should be invoked only under certain extreme circumstances which would include special management actions such as drawdowns in the Kissimmee Chain of Lakes upstream of Lake Okeechobee, temporary structural impediments to normal operations (*e.g.,* construction or maintenance of structures downstream from the lake), or immediately preceding or following emergencies such as hurricanes. We do not agree that anticipated weather conditions should be posed as a rationale for additional operational flexibility. The established decision trees already incorporate the widely accepted meteorological information available to water mangers, including the tributary conditions, the Palmer Index, the net inflow forecast, the El Niño/Southern Oscillation, and the seasonal forecasts from the National Weather Service's Climate Prediction Center. We also ask that the Corps describe in greater detail the deliberation and notification process that would lead to a decision to invoke additional operational flexibility. It is appropriate for interested agencies and the general public to have advanced notification and an explanation of what prompted the need, what the objectives are, and the limits of the events.

14. The period of record for the simulations should be extended to include the water years 2000 through 2005. This is important because this period included a drought with the lowest recorded water stage in Lake Okeechobee (8.97 ft on May 23, 2001) and because it also includes the extremely active hurricane seasons of 2004 and 2005.

15. In the next phase of the regulation schedule revision, water supply deliveries from Lake Okeechobee to the EAA during drought should not exceed those in the current version of the LOWSM. Any additional removal of water from the lake through the permanent forward pumps than is currently predicted to occur through the temporary forward pumps would likely have severe impact on the ecology of the lake, including an even greater likelihood of MFL violations. If water demands are projected to increase from the Lake Okeechobee Service Area, these should be met through efficient operation of the planned EAA Reservoir, rather than through additional discharges through the permanent forward pumps.

XI. SUMMARY OF POSITION

The Service has participated in the development and review of alternatives for the current regulation schedule since the initiation of this project. Throughout the evaluation process we provided recommendations involving the refinement and selection of project alternatives based on ecological considerations within Lake Okeechobee, the Caloosahatchee and St. Lucie estuaries, and the greater Everglades ecosystem. Each PDT member agency has advocated the selection of alternatives that best met that agency's goals and mission, and the Service has consistently recommended the adoption of a new regulation schedule that would improve the ecological performance of the existing schedule across the entire spectrum of ecological resource concerns.

The Service believes that the TSP, on balance, will improve ecological conditions within Lake Okeechobee's littoral zone by reducing the extent and duration of extreme high water elevations during wet seasons and storm events. However, this improvement may be partially offset by an increased likelihood of extreme low water levels during dry seasons and local or regional droughts. The St. Lucie estuary will benefit somewhat from the proposed change to the regulation schedule by reducing the excessively high freshwater flows that have plagued that ecosystem in recent years, and by significantly reducing the incidence of low flow events. The proposed change to the schedule will benefit the Caloosahatchee's upper estuary by increasing base flow during dry times that will reduce the number of times the estuary suffers from too high salinity. The Caloosahatchee will also receive less water during wet season releases, decreasing the frequency of some classes of damaging high flow events, but somewhat increasing the severity and duration of the remaining high flow events, which could increase environmental degradation in the lower estuary. Whether or not this tradeoff will result in a net benefit or net impact to the Caloosahatchee is dependent upon the weather conditions of the next three years. If the increased tropical storm activity experienced during the past several years continues, both the Caloosahatchee and St. Lucie estuaries will likely continue to be negatively impacted by lake releases. On the contrary, if the next 3 years include a severe or extended drought, the new schedule brings an increased risk of adverse impacts in drying out the littoral zone of the lake.

The Lake Okeechobee regulation schedule will be revised again in 2010. The current revision of the schedule will provide lessons for improved understanding of how well the current water management infrastructure can handle extreme weather events, and we have already identified several additional analysis tools and methods that should be used in the upcoming revision process. Although this current revision to the schedule does not adequately meet all the needs and desires of the competing lake interests, the next revision to the schedule, with the additional water management infrastructure that is assumed to be in place at that time, will likely approach more closely the goal of balanced and shared adversity as it relates to water demands from Lake Okeechobee.

XII. LITERATURE CITED

American Rivers. 2006. America's Most Endangered Rivers of 2006. http://www.americanrivers.org/site/DocServer/Caloosahatchee_MER2006.pdf?docID=3881.

Bortone, S.A. and R.K. Turpin. 1999. Tape grass life history metrics associated with environmental variables in a controlled estuary. In *Seagrasses: Monitoring, Ecology, Physiology, and Management*, S.A. Bortone (ed.). CRC Press, Boca Raton, pp. 65-79.

Bulger, A.J., B.P. Hayden, M.G. McCormick-Ray, M.E. Monaco, and D.M. Nelson. 1990. A proposed estuarine classification: analysis of species salinity ranges. ELMR Report No. 5, Strategic Assessment Branch, NOS/NOAA, Rockville, Md.

Bull, L.A., D.D. Fox, D.W. Brown, L.J. Davis, S.J. Miller, and J.G. Wullschleger. 1995. Fish distribution in limnetic areas of Lake Okeechobee, Florida. Pp. 333-342 *in* Aumen, N.G. and R.G. Wetzel, eds. 1995. Ecological studies on the littoral and pelagic systems of Lake Okeechobee, Florida (USA). Arch. Hydrobiol. Beih. Ergebn. Limnol. 45.

Chamberlain, R. H. and P.H. Doering. 1998a. Freshwater inflow to the Caloosahatchee Estuary and the resource-based method for evaluation. In *Proceedings of the Charoltte Harbor Public Conference and Technical Symposium,* S.F. Treat (ed.). Charlotte Harbor Estuary Program, Tech. Rep. No. 98-02, North Fort Myers, Florida, pp. 88-91.

Chamberlain, R. H. and P.H. Doering. 1998b. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary: A resource based approach.. In *Proceedings of the Charoltte Harbor Public Conference and Technical Symposium,* S.F. Treat (ed.). Charlotte Harbor Estuary Program, Tech. Rep. No. 98-02, North Fort Myers, Florida, pp. 111-120.

Chamberlain, R.H., D.E. Haunert, P.H. Doering, K.M. Haunert, and J.M. Otero. 1995. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary, Florida. Technical Report, South Florida Water Management District. West Palm Beach, Florida.

Darby, P.C. 2005. Apple snail abundance in snail kite foraging sites on Lake Okeechobee in 2005. Annual report submitted to the Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, June 2005.

Darby P.C., R.E. Bennetts, S.J. Miller and H.F. Percival. 2002. Movements of Florida apple snails in relation to water levels and drying events. Wetlands. 22(3): 489-498.

Darby, P.C., P.L. Valentine-Darby and H.F. Percival. 2003. Dry season survival in a Florida apple snail (*Pomacea paludosa* Say) population. Malacologia. 45(1): 179-184.

Darby, P.C., P.L. Valentine-Darby, H.F. Percival and W.M. Kitchens. 2004. Florida apple snail (*Pomacea paludosa* Say) responses to lake habitat restoration activity. Arch. Hydrobiol. 161(4): 561-575.

David, P.G. 1994a. Wading bird use of Lake Okeechobee relative to fluctuating water levels. Wilson Bulletin 106:719-732.

David, P.G. 1994b. Wading bird nesting at Lake Okeechobee, Florida: An historical perspective. Colonial Waterbirds 17:69-77.

Doering, P.H., R.H. Chamberlain, and D.E. Haunert. 2002. Using submerged aquatic vegetation to establish minimum and maximum freshwater inflows to the Caloosahatchee Estuary, Florida. Estuaries 25(6B): 1343-1354.

Estevez, Ernest. 1998. The story of the greater Charlotte Harbor watershed. Charlotte Harbor National Estuary Program, Fort Myers, Florida, 135 pp.

Fox, D. 2007. Personal communication. Biologist, Florida Fish and Wildlife Conservation Commission. Telephone conversation with Robert Pace, January 19, 2007.

Furse, J.B. and D.D. Fox. 1994. Economic fishery valuation of five vegetation communities in Lake Okeechobee, Florida. Proceedings of the Annual Conference of Southeast Association of Fish and Wildlife Agencies 48:575-591.

Gunter, G. 1953. The relationship of the Bonnet Carre spillway to oyster beds in Mississippi Sound and the Louisiana marsh, with a report on the 1950 opening. Publ. Inst. Mar. Sci. Univ. Tex 3(1): 17-71.

Harris, B.A., K.D. Haddad, K.A. Steidinger, and J.A. Huff. 1983. Assessment of Fisheries Habitat: Charlotte Harbor and Lake Worth, Florida. Florida Department of Natural Resources, Bureau of Marine Research, St. Petersburg, Florida. 211 pp.

Haunert, D., B. Chamberlain, P. Doering, and K. Konyha. 2000. Draft Technical criteria to guide an adaptive management strategy for minimum flows to the Caloosahatchee Estuary, Florida. South Florida Water Management District. West Palm Beach, Florida.

Havens, K.E. 1997. Water levels and total phosphorus in Lake Okeechobee. Lake and Reservoir Management 12:78-90.

Havens, K.E. 2005. Rehabilitation of Lake Okeechobee from impacts of high water and hurricanes: recommendations regarding a controlled water level recession (draw-down). South Florida Water Management District. West Palm Beach, Florida.

Havens, K.E., N.G. Aumen, R.T. James, and V.H. Smith. 1996a. Rapid ecological changes in a large subtropical lake undergoing cultural eutrophication. Ambio 25:150-155.

Havens, K.E., L.A. Bull, G.L. Warren, T.L. Crisman, E.J. Phlips, and J.P. Smith. 1996b. Food web structure in a subtropical lake ecosystem. Oikos 75:20-32.

Havens, K.E., D. Fox, S. Gornak, and C. Hanlon. 2005. Aquatic vegetation and largemouth bass population responses to water-level variations in Lake Okeechobee, Florida (USA). Hydrobiologia 539:225–237.

Havens, K.E. and D.E. Gawlik. 2005. Lake Okeechobee conceptual ecological model. Wetlands 25(4):908–925.

Havens, K.E. and R.T. James. 1999. Localized changes in transparency linked to mud sediment expansion in Lake Okeechobee, Florida: Ecological and management implications. Lake and Reservoir Management 15(1):54-69.

Janus, L.L., D.M. Soballe, and B.L. Jones. 1990. Nutrient budget analyses and phosphorus loading goal for Lake Okeechobee, Florida. Verh. Internat. Verein. Limnol. 24:538-546.

Kimes, C.A. and L.C. Crocker. 1998. The Caloosahatchee River and Its Watershed. Florida Center for Environmental Studies Agreement #SR 819 FAU DSR #96-127, South Florida Water Management District, Florida.

Lindall, W.N. Jr. 1973. Alterations of estuaries of south Florida: A threat to its fish resources. Marine Fisheries Review, Vol. 35, No. 10, NMFS, pp1-8.

Lockhart, C., D.F. Austin, and N. G. Aumen. 1999. Water level effects on growth of melaleuca seedlings from Lake Okeechobee (Florida, USA) littoral zone. Environmental Management. 23(4): 507-518.

Maceina, M.J. 1993. Summer fluctuations in planktonic chlorophyl *a* concentrations in Lake Okeechobee, Florida: The influence of lake levels. Lake and Reservoir Management 8:1-11.

MacKenzie, C.L. Jr. 1977. Development of an aquacultural program for rehabilitation of damaged oyster reefs in Mississippi. U.S. Natl. Mar. Fish. Serv. Mar. Fish Rev. 39(8): 1-3.

Martin J., W. Kitchens, C. Cattau, A. Bowling, M. Conners, D. Huser and E. Powers. 2006. Snail Kite Demography Annual Report 2005. Annual report submitted to the US Fish and Wildlife Service, Vero Beach, Florida, February 2006.

McMahan, C.A., 1968. Biomass and salinity tolerance of shoal grass and manatee grass in Lower Laguna Madre, Texas. Journal of Wildlife Management 33:501-506.

Milleson, J.F. 1987. Vegetation changes in the Lake Okeechobee littoral zone: 1972 to 1982. Technical Publication 87-3. South Florida Water Management District. West Palm Beach, Florida.

Pesnell, G.L. and R.T. Brown. 1977. The major plant communities of Lake Okeechobee, Florida, and their associated inundation characteristics as determined by gradient analysis. Technical Publication 77-1. South Florida Water Management District. West Palm Beach, Florida.

Richardson, J.R. and T.T. Harris. 1995. Vegetation mapping and change detection in the Lake Okeechobee marsh ecosystem. Pp. 17-39 *in* Aumen, N.G. and R.G. Wetzel, eds. 1995. Ecological studies on the littoral and pelagic systems of Lake Okeechobee, Florida (USA). Arch. Hydrobiol. Beih. Ergebn. Limnol. 45.

Richardson, J.R. T.T. Harris, and K.A. Williges. 1995. Vegetation correlations with various environmental parameters in the Lake Okeechobee marsh ecosystem. Pp. 41-61 *in* Aumen, N.G. and R.G. Wetzel, eds. 1995. Ecological studies on the littoral and pelagic systems of Lake Okeechobee, Florida (USA). Arch. Hydrobiol. Beih. Ergebn. Limnol. 45.

Sackett, J.W. 1888. Survey of Caloosahatchee River, Florida. Report to the Captain of the U.S. Engineering Office. St. Augustine, Florida.

Schlesselman, G.W. 1955. The gulf coast oyster industry of the United States. Geograph. Rev. 45(4): 531-541.

Smith, J.P., and M.W. Collopy. 1995. Colony turnover, nest success and productivity, and causes of nest failure among wading birds (Ciconiiformes) at Lake Okeechobee, Florida, (1989-1992). Pp. 287-316 *in* Aumen, N.G. and R.G. Wetzel, eds. 1995. Ecological studies on the littoral and pelagic systems of Lake Okeechobee, Florida (USA). Arch. Hydrobiol. Beih. Ergebn. Limnol. 45.

Smith, J.P., J.R. Richardson, and M.W. Collopy. 1995. Foraging habitat selection among wading birds (Ciconiiformes) at Lake Okeechobee, Florida, in relation to hydrology and vegetative cover. Pp. 247-285 *in* Aumen, N.G. and R.G. Wetzel, eds. 1995. Ecological studies on the littoral and pelagic systems of Lake Okeechobee, Florida (USA). Arch. Hydrobiol. Beih. Ergebn. Limnol. 45.

South Florida Water Management District. 2000a. Draft Minimum Flows & Levels for Lake Okeechobee, the Everglades, and the Biscayne Aquifer. South Florida Water Management District. West Palm Beach, Florida.

South Florida Water Management District. 2000b. Technical documentation to support development of minimum flows and levels for the Caloosahatchee River and Estuary. South Florida Water Management District, Florida.

South Florida Water Management District. 2002. Technical documentation to support development of minimum flows and levels for the Caloosahatchee River and Estuary: Draft Status Update Report. South Florida Water Management District, Florida.

South Florida Water Management District. 2003. Existing legal Sources for the Caloosahatchee Estuary at the Franklin Lock and Dam (S-79). Coastal Ecosystems Division, Southern Restoration Department, South Florida Water Management District, Florida.

South Florida Water Management District. 2006a. 2006 South Florida Environmental Report, Volume 1. South Florida Water Management District. West Palm Beach, Florida.

South Florida Water Management District. 2006b. Draft 2007 South Florida Environmental Report, Volume 1. South Florida Water Management District. West Palm Beach, Florida.

Steinman, A.D., K.E. Havens, N.G. Aumen, R.T. James, K-R. Jin, J. Zhang, and B.H. Rosen. 1998. Phosphorus in Lake Okeechobee: Sources, sinks, and strategies. *In* Reddy, K.R. (ed.). Phosphorus biogeochemistry in Florida ecosystems. Lewis Publishing Co.; Boca Raton, Florida.

Steinman, A.D., K.E. Havens, and L. Hornung. 2002. The managed recession of Lake Okeechobee, Florida: integrating science and natural resource management. Conservation Ecology 6(2): 17.

Sutton, D.L. 1996. Growth of torpedo grass from rhizomes planted under flooded conditions. Journal of Aquatic Plant Management 34:50-53.

U.S. Corps of Engineers, 1957. General Design Memorandum, Caloosahatchee River and control structures (Canal 43 and lock and spillway structures 77, 78, and 79), Part IV: Central and Southern Florida Project. U.S. Army Corps of Engineers, Serial No.36.

U.S. Army Corps of Engineers. 1995. Environmental assessment and finding of no significant impact (FONSI) for modification of the water regulation schedule for Water Conservation Area No. 1. Central and South Florida Flood Project for flood control and other purposes. March 1995. U.S. Army Corps of Engineers, Jacksonville District, Jacksonville, Florida.

U.S. Army Corps of Engineers. 2005. Intent To Prepare a Draft Supplemental Environmental Impact Statement for the Lake Okeechobee Regulation Schedule Study of the Central and Southern Florida Project for Flood Control and Other Purposes, Lake Okeechobee, FL. August 3, 2005. Federal Register 70(148): 44585-44586.

U.S. Army Corps of Engineers. 2006. Draft Supplemental Environmental Impact Statement. Lake Okeechobee regulation schedule study. U.S. Army Corps of Engineers, Jacksonville District; Jacksonville, Florida.

Volety, A.K., S.G. Tolley, and J.T. Winstead. 2003. Effects of seasonal and water quality parameters on oysters (Crassostrea virginica) and associated fish populations in the Caloosahatchee River: Final contract report (C-12412) to the South Florida Water Management District. Florida Gulf Coast University, Ft. Myers, Florida.

Warren, G.L., M.J. Vogel, and D.D. Fox. 1995. Trophic and distributional dynamics of Lake Okeechobee sublittoral benthic invertebrate communities. Pp. 317-332 *in* Aumen, N.G. and R.G. Wetzel, eds. 1995. Ecological studies on the littoral and pelagic systems of Lake Okeechobee, Florida (USA). Arch. Hydrobiol. Beih. Ergebn. Limnol. 45.

Zaffke, M. 1984. Wading bird utilization of Lake Okeechobee marshes: 1977-1981. Technical Publication 84-9. South Florida Water Management District: West Palm Beach, Florida.

Zieman, J.C. and R.T. Zieman, 1989. the ecology of the seagrass meadows of the west coast of Florida: a community profile. U.S. Fish and Wildlife Service Biological Report 85 (7.25) 155pp.

Table 1. Performance Measure Output by Alternative for the Caloosahatchee Estuary.

	monthly <450cfs	basin monthly >2800cfs	LOK monthly >2800cfs	total monthly >2800cfs	monthly >2800 <4500	monthly >4500cfs	moving weekly >4500cfs >5 weeks	moving weekly >4500cfs >12 weeks
Target		26	0	26		7		
07LORS_102006	198	40	34	74	45	29	28	0
alt1bS2-aLOWSM	104	39	29	68	32	36	88	0
alt1bS2-mLOWSM	105	39	31	70	35	35	83	13
alt1bS2-T1	116	39	30	69	35	34	66	13
alt1bS2-T2	131	38	25	63	34	29	79	0
alt1bS2-T3	131	37	27	64	35	29	65	0

= CERP Performance Measure Targets
= Worse than baseline (07LORS) alternative
= Best performance of alternatives that are worse than base.
= Equal to or slightly better than base
= Much better than base
= Best

Table 2. Performance Measure Output by Alternative for the St. Lucie Estuary.

	monthly <350cfs	basin bi-weekly >2000cfs	LOK bi-weekly >2000cfs	total bi-weekly >2000cfs	monthly >2000cfs <3000cfs	monthly >3000cfs	total monthly >2000cfs
Target	207	28	0	28	18	5	23
07LORS_102006	127	72	52	124	43	31	74
alt1bS2-aLOWSM	129	71	49	120	36	30	66
alt1bS2-mLOWSM	129	71	49	120	38	27	65
alt1bS2-T1	123	70	46	116	37	28	65
alt1bS2-T2	103	79	54	133	44	31	75
alt1bS2-T3	103	79	49	128	42	31	73

= CERP Performance Measure Targets
= Worse than baseline (07LORS) alternative
= Equal to or slightly better than base
= Much better than base
= Best

Table 3. Performance Measure Output by Alternative for Lake Okeechobee.

	Low Stage <11 ft for >80 days	Low Stage <11 ft	Low Stage <12 ft for >365 days	Low Stage # days <12.56	High Stage >17 ft	High Stage >17.25 ft for >7 days	High Stage >17.5 ft for >7 days	High Stage >15 ft for 365 days	Stage Envelope % time inside
07LORS_053106	3	12	1	2577	9	6	7	2	30.3%
07LORS_102006	5	11	1	2876	11	8	7	2	27.5%
alt1bS2-aLOWSM	6	20	2	4839	4	1	0	0	26.6%
alt1bS2-mLOWSM	7	21	2	4922	2	0	0	0	27.0%
alt1bS2-T1	8	17	2	4909	2	0	0	0	27.3%
alt1bS2-T2	6	19	2	5156	3	1	0	0	25.4%
alt1bS2-T3	6	23	2	5128	2	1	0	0	25.3%

= Worse than baseline (07LORS) alternative
= When all alternatives are worse than baseline, this is the least worst.
= Much better than base
= Best

APPENDIX A

Evaluation tables for preliminary alternatives.

Table A-1. Performance Measure Output by Alternative for the Caloosahatchee Estuary.

	monthly <450cfs	basin monthly >2800cfs	LOK monthly >2800cfs	total monthly >2800cfs	monthly >2800 <4500	monthly >4500cfs	moving weekly >4500cfs >5 weeks	moving weekly >4500cfs >12 weeks
Target		26	0	26		7		
07LORS	195	40	40	80	46	34	43	0
LORS-fwo	103	40	37	77	44	33	26	0
Alt1a	143	39	33	72	35	37	43	0
Alt1aS1	125	39	32	71	34	37	42	0
Alt1aS2	113	39	32	71	36	35	41	0
Alt1b	144	39	34	73	34	39	73	14
Alt1bS1	135	39	34	73	35	38	70	0
Alt1bS2	114	39	36	75	39	36	69	0
Alt1bS2-A	114	39	36	75	39	36	68	0
Alt1bS2-m	117	39	34	73	36	37	72	13
Alt2a	136	39	40	79	38	41	56	14
Alt2a-A	136	39	40	79	38	41	56	14
Alt2a-B	134	39	41	80	40	41	56	14
Alt2a-m	128	36	34	70	33	37	46	0
Alt2b	174	39	47	86	43	43	115	32
Alt2bS1	144	39	45	84	43	41	103	16
Alt3	199	41	27	68	37	31	91	48
Alt3-B	96	40	21	61	31	30	62	0
alt-4	128	39	34	73	36	37	57	13
Alt4-A	128	39	32	71	34	37	57	13

= CERP Performance Measure Targets
= Worse than baseline (07LORS) alternative
= Much better than base
= Best

Table A-2. Performance Measure Output by Alternative for the St. Lucie Estuary.

	monthly <350cfs	basin bi-weekly >2000cfs	LOK bi-weekly >2000cfs	total bi-weekly >2000cfs	monthly >2000cfs <3000cfs	monthly >3000cfs	total monthly >2000cfs
Target	207	28	0	28	18	5	23
07LORS	128	72	50	122	44	31	75
LORS-fwo	130	71	43	114	38	30	68
Alt1a	126	71	54	125	43	26	69
Alt1aS1	126	71	52	123	43	25	68
Alt1aS2	126	71	50	121	42	25	67
Alt1b	126	71	51	122	41	28	69
Alt1bS1	126	71	49	120	40	27	67
Alt1bS2	126	71	51	122	42	26	68
Alt1bS2-A	126	71	50	121	42	26	68
Alt1bS2-m	127	70	54	124	36	29	65
Alt2a	129	66	69	135	38	36	74
Alt2a-A	129	66	69	135	38	36	74
Alt2a-B	135	66	68	134	38	36	74
Alt2a-m	118	71	58	129	39	34	73
Alt2b	131	68	63	131	49	25	74
Alt2bS1	136	68	60	128	47	24	71
Alt3	130	72	48	120	36	32	68
Alt3-B	131	72	38	110	34	30	64
alt-4	127	68	48	116	37	30	67
Alt4-A	127	69	46	115	37	30	67

= CERP Performance Measure Targets
= Worse than baseline (07LORS) alternative
= Much better than base
= Best

Table A-3. Performance Measure Output by Alternative for Lake Okeechobee.

	Low Stage <11 ft for >80 days	Low Stage <11 ft	Low Stage <12 ft for >365 days	Low Stage # days <12.56	High Stage >17 ft	High Stage >17.25 ft for >7 days	High Stage >17.5 ft for >7 days	High Stage >15 ft for 365 days	Stage Envelope % time inside
07LORS	3	12	1	2557	9	6	7	2	30.3%
LORS-fwo	5	12	1	3336	11	3	2	2	29.8%
Alt1a	6	14	1	3797	10		2	1	28.2%
Alt1aS1	7	13	2	4062	8		2	1	27.2%
Alt1aS2	7	15	2	4532	8	2	2	1	26.8%
Alt1b	5	20	1	3976	2		0	0	29.0%
Alt1bS1	7	16	2	4300	3		0	0	28.0%
Alt1bS2	6	20	2	4809	2	1	0	0	26.9%
Alt1bS2-A	6	20	2	4809	2	1	0	0	27.3%
Alt1bS2-m	7	22	2	4842	2	0	0	0	27.9%
Alt2a	8	21	2	5229	1	0	0	0	31.7%
Alt2a-A	8	21	2	5229	1	0	0	0	
Alt2a-B	8	19	2	5141	1	0	0	0	32.1%
Alt2a-m	9	26	2	5776	1	0	0	0	27.8%
Alt2b	6	13	1	4101	1		0	0	34.0%
Alt2bS1	6	18	2	4611	1		0	0	29.6%
Alt3	4	10	1	2782	13	9	8	1	23.5%
Alt3-B	6	14	1	3260	15	7	2	0	24.8%
alt-4	9	19	2	4846	2	1	0	0	29.3%
Alt4-A	9	19	2	4841	2	0	0	0	29.6%

= Worse than baseline (07LORS) alternative
= Best performance of alternatives that are worse than base
= Much better than base
= Best

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